# IEP Long-Term Fish Monitoring Program Element Review

Interagency Ecological Program

COOPERATIVE ECOLOGICAL INVESTIGATIONS SINCE 1970

**December 2004**

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## List of Acronyms

**AdBass –** Adult Striped Bass
**AdSturg –** Adult Sturgeon
**BDA** - California Bay-Delta Authority (formerly CALFED)
**BSeine –** Beach Seine
**CALFED** - California & Federal Agencies Bay-Delta Program
**CCWD** - Contra Costa Water District
**CVP** - Central Valley Project
**DFG** - California Department of Fish & Game
**DWR** - California Department of Water Resources
**EBMUD** - East Bay Municipal Utility District
**EPA** - United States Environmental Protection Agency
**ESA -** Endangered Species Act
**FMWT –** Fall Midwater Trawl
**IEP** - Interagency Ecological Program
**JuvStur -** Juvenile Sturgeon
**Mok R** - Mokelumne River
**MWT** - Midwater trawl
**NBA** - North Bay Aqueduct
**NMFS** - National Marine Fisheries Service
**NOAA** - National Oceanic & Atmospheric Administration
**OCAP** - Operations Criteria Assessment and Plan
**ResFish –** Resident Fish
**rm** - river mile
**RTM** – Realtime Monitoring
**Sac R** - Sacramento River
**SFB** - San Francisco Bay
**SFEI** - San Francisco Estuary Institute
**SJ Delta** - San Joaquin Delta
**SJR** - San Joaquin River
**SL** - slough
**SPB** - San Pablo Bay
**SprKod –** Spring Kodiak
**SuisM –** Suisun Marsh
**SWRCB** - State Water Resources Control Board
**SWP** - State Water Project
**TNS** - Townet Survey
**UCD** - University of California, Davis
**USBR** - United States Bureau of Reclamation
**USFWS** - United States Fish and Wildlife Service
**USGS** - United States Geological Survey

## 1. Introduction

In spring 2004, we, the authors, initiated a review of the Interagency Ecological Program (IEP) fish monitoring program elements on behalf of the IEP Management Team. The fish monitoring program elements constitute a substantial portion of IEP's overall monitoring efforts. These program elements represent some of IEP's longest standing monitoring elements, collecting data used for decades by scientists and resource managers throughout the San Francisco Estuary (Figure 1.1). Given their importance and prominence, IEP management[1] requested a programmatic review of its fish monitoring program elements to assemble relevant information that can help in the ongoing management and implementation of IEP. In addition, IEP management expects to use information from this review in future decisions about performing more in-depth program element reviews, and in setting overall program priorities and resource commitments. Finally, IEP management is completing a strategic plan, which together with this programmatic review will provide essential information for longer-term program planning, including addressing critical gaps in IEP monitoring efforts. Based on these IEP management needs, the overall goal for this review is to:

> *Gather and synthesize project-specific information to educate IEP management about its fish monitoring program elements and how the project products are used, and to help managers in making decisions about longer-term program priorities and resource commitments.*

Unlike recent program element reviews, no new technical analyses were completed as part of this review. Instead, this review relies on information obtained from completion of a detailed questionnaire (see Appendix A), with the assumption that much of the requested information already exists in a readily available form.

This review offers the first comprehensive summary of information for all IEP fish monitoring programs. This review is not, however, designed to identify specific program cuts, to provide technical review of sampling design, nor to establish program priorities. Information within the questionnaire responses and this summary should help forward such objectives, but additional information is required to fully inform these types of decisions. This report serves as an initial foundation for IEP to build upon in meeting its future planning and implementation challenges.

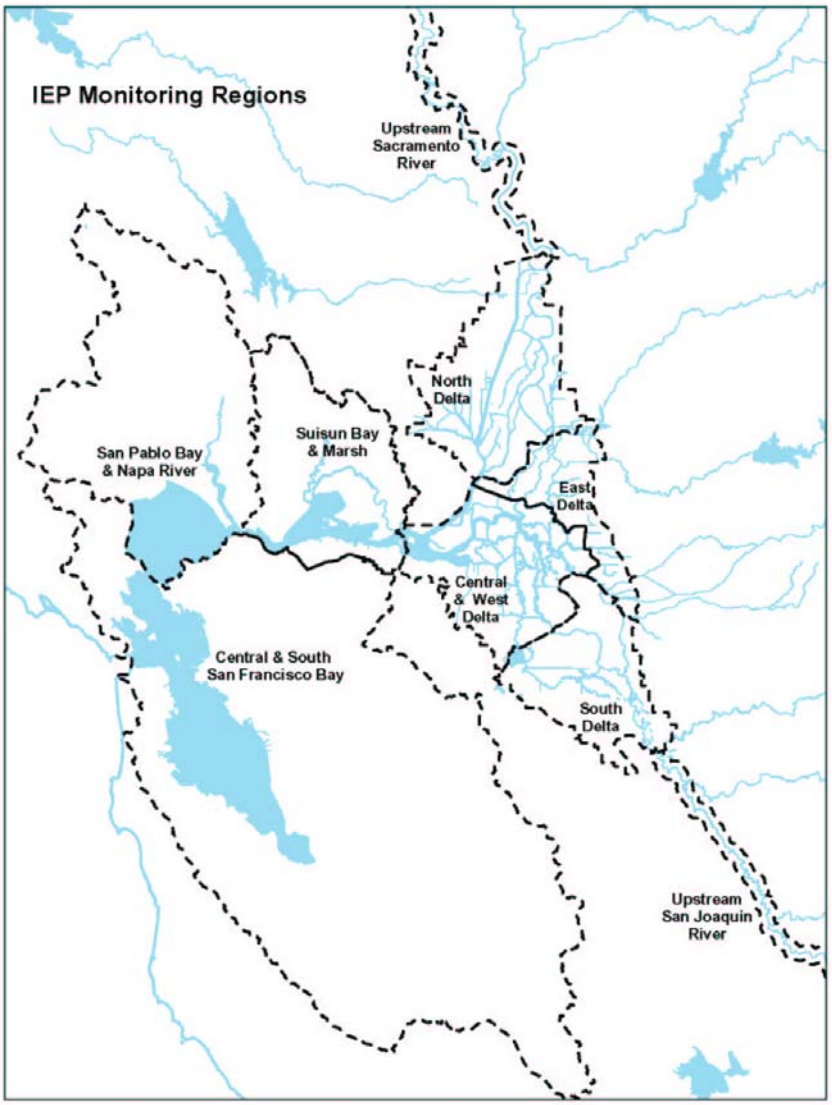
This review is based on data gathered in spring 2004 for active IEP fish monitoring program elements. These data reflect the current role and sampling protocol for each IEP fish monitoring program element, as well as products produced between 1994 and 2003. Information on historical activities was not gathered as part of this review, so there is no explicit analysis to determine how the purpose or methods may have changed over time. Historic survey components not currently in use and not reviewed include: (1) Striped Bass Larva Sampling, (2) Bay Study Beach Seine; (3) Bay Study Plankton Sampling; (4) Spring Midwater Trawl Survey (transformed to Spring Kodiak Trawl Survey); and (5) Suisun Marsh Larva Survey. Furthermore, the roles of many surveys have broadened over time. For example, information gathered on the Fall Midwater Trawl Survey reports a current focus on

[1] For purposes of this document, IEP management refers to the IEP Management Team, the IEP Coordinators, or both groups.

monitoring the distribution and abundance of delta smelt, in addition to the historical focus on monitoring the abundance and distribution of young striped bass. Similar changes have occurred in the State Water Project (SWP) and Central Valley Project (CVP) Fish Salvage programs, which initially focused on estimating the salvage of salmon and striped bass.

Throughout this report we primarily summarize questionnaire responses as received; however, we also draw on our own understanding of the fish monitoring program elements, best professional judgment, and other sources of information to augment questionnaire responses. This supplemental information enabled us to increase consistency in the level of survey detail and information. For example, not all questionnaire respondents reported their budgets and costs in a consistent manner (e.g., boat operators and cost accounting were excluded in some reported survey costs). To adjust for this information gap, we used IEP annual budget information to compare among all surveys. In such instances when outside data supplements questionnaire responses, we highlight the need for supplemental information, as well as the contributing sources. Such supplemental information has been verified through personal communication with questionnaire respondents or through a general comment period.

**Figure 1.1. San Francisco Estuary Monitoring Regions**




This report begins with a summary of basic information and descriptions of the IEP fish monitoring program elements. Next, the report presents a summary of budgetary and resource information. A majority of the report is devoted to a synthesis of information related to how the fish monitoring program elements are meeting overall IEP goals and an examination of program element strengths and weaknesses. In an effort to examine program element outputs and use, the report also summarizes information on data products and reporting, and customer use. The report concludes with a summary of additional comments received from completed questionnaires.

## 2. Basic Information and Program Element Description

This effort summarizes and synthesizes project-specific information about 16 IEP fish monitoring program elements (i.e., surveys) and describes how their monitoring survey products are used by agency personnel, academic researchers, and other resource management interests.

Appendix A includes the original questionnaire goals, timeline, and IEP mission and goals presented to respondents in spring 2004. Appendix B contains unabridged survey responses for all 19 questionnaires (multiple Beach Seine and Salvage Facility responses are combined for summary and synthesis) that responded with information about these 16 surveys.

Table 2.1 summarizes basic information and program element descriptions for the 16 surveys. The surveys, conducted by five different organizations, all focus on fish monitoring within the San Francisco Estuary which includes portions of the Delta (Figure 1.1). The majority of surveys target species of concern and those listed under the Federal and State Endangered Species Act (ESA), namely: winter-run Chinook salmon, spring-run Chinook salmon, Central Valley steelhead, coastal steelhead, delta smelt, and splittail. Fall-run Chinook, striped bass, and other sport fishes also emerged as significant monitoring targets.

The regulatory and management value of fish survey information has led to direct and indirect incorporation of some program elements into the terms and conditions for CVP and SWP operations regulatory documents through Endangered Species Act Consultations or Water Right Decisions. When incorporated into Operations Criteria Assessment Plans (OCAPs) or Water Rights Decisions a survey becomes mandated monitoring. Here we distinguish two types of mandates: 1) a survey is considered “mandated” when listed by name in the terms and conditions of a Biological Opinion or a Water Right Order; or 2) a survey is considered to have a “soft mandate” when it strongly or solely contributes to a specific term or condition (e.g. “Real-time Monitoring” is mandated by the 2004 NOAA OCAP; four USFWS surveys, and one each from CVP and SWP contribute directly and substantially to Real-time Monitoring).

Eleven of sixteen surveys fall into one or both of these categories; the most recent mandates are identified for each survey (Table 2.1). The soft mandate category contains program elements broadly construed as responses to a recent OCAP (previous example) or orders within the current Water Right Decision for San Francisco Bay and the Sacramento-San Joaquin Delta Estuary, Decision 1641, such as:

> 11.b. Conduct ongoing and future monitoring surveys as recommended by the DFG, the USFWS or the National Marine Fisheries Service (NMFS), and acceptable to the Executive Director of the SWRCB concerning food chain relationships, fisheries impacts, or impacts to brackish tidal marshes, as they are affected by operations of the SWP or the CVP in the Delta and Suisun Marsh (Decision 1641, pg 149).

Decision 1641 maintains intact several orders from the previous Water Right Decision, 1485, including:

10 (c) Participate in research studies to determine:

i) Outflow needs in San Francisco Bay, including ecological benefits of unregulated outflows and salinity gradients established by them.

ii) The need for winter flows for long-term protection of striped bass and other aquatic organisms in the Delta (Decision 1485, pg 30).

Order 10 (c) i) led directly to the implementation of the Bay Study Survey.

None of the aforementioned mandates preclude necessary changes; however, they do indicate the need for regulatory consultation when large-scale changes are anticipated. Terms of Water Rights Decisions, in particular, leave broad latitude for agency interpretation and implementation.

Generally, the evolution of IEP fish monitoring program elements occurred in stages spanning almost five decades (late 1950s through the 1990s). This evolution tracks the shifting concern for select fish species and the programmatic response of IEP. Initially (1950s – 1960s) two geographically broad surveys (Summer Townet and Fall Midwater Trawl) were implemented to sample the distribution and abundance of age-0 striped bass and the pelagic fish community in the Delta and upper estuary. Also in 1960s, more narrowly targeted surveys were added to monitor the abundance of select sport fishes, white sturgeon and striped bass. Analyses of data from existing surveys began to also emphasize results for sport fish. IEP fish monitoring program elements continued to focus on sport fishes in 1970s. Three new surveys were added (USFWS beach seine, the Sacramento River trawl, and the Chipps Island trawl), which focused on tracking the timing and abundance of emigrating juvenile Chinook salmon. Also beginning in the 1970s, salvage data from the SWP and CVP were regularly used to estimate the salvage of striped bass and salmon resulting from Delta exports. Analyses of data from existing surveys continued to focus heavily on trends in the abundance of sport fishes, particularly striped bass and Chinook salmon. Two new fish community surveys, the Bay Study and Suisun Marsh survey, were initiated in the 1980s to monitor fish communities in under-sampled areas of the Estuary. These new surveys also used methods to estimate the abundance of demersal fish species, as well as pelagic fish species in the case of Bay Study. From the 1960s to early 1990s, striped bass was considered the key indicator fish species for the upper estuary and Delta, and much of the analyses of fish monitoring data focused on this species, but concerns about increased water exports also led to analyses of flow effects on abundance of a suite of sport and native species, concluding in the first X2 publications (X2 or the location of 2 ppt bottom salinity is used as a species habitat indicator whose position is influenced by outflow). In the 1990s several native fishes were listed as threatened (delta smelt, splittail, central valley and coastal steelhead, and spring-run Chinook salmon) or endangered (winter-run Chinook salmon) under the Federal or State Endangered Species acts. A few other species were considered candidates for listing (longfin smelt, San Joaquin fall-run Chinook salmon, and green sturgeon). These listings resulted in a shift in analysis and reporting with greater emphasis on listed species in particular and native species in general. In addition, several new surveys were added (20 mm Survey, North Bay Aqueduct Survey, Spring Kodiak Trawl) that targeted delta smelt, and others expanded (Fall Midwater Trawl

geographically and temporally, into spring). Surveys for Chinook salmon were expanded temporally (Beach Seine, and Chipps Island, Sacramento and Mossdale trawls). Much of the larval fish sampling was discontinued in the 1990s due to the high cost and underutilization of these data. Finally, a shoreline fishes survey was implemented in the mid-1990s based in part on the realization that this important Delta community was poorly sampled and understood.

Despite the shifting emphasis on different target species, the IEP fish monitoring program elements have not experienced many changes in methodology throughout the past five decades. This constancy in sampling techniques and locations has created substantial long-term records of tremendous value to agency, consultant, and academic customers. The constancy has not, however, prevented survey expectations, objectives, and goals from changing to reflect evolving priorities. While several surveys have been added and some discontinued as a result of shifting emphasis, shifts in emphasis of data analysis and reporting also strongly reflect evolving priorities.

## 2.1. Sampling strategies

To facilitate information synthesis and report analysis, we assigned the 16 long-term monitoring surveys to one of four categories based upon survey design (Table 2.1). Nine of the surveys are designed to sample fishes somewhat systematically through varying portions of the estuary (Surveys 1-9, Table 2.1). Eight of the nine surveys —all except Juvenile Sturgeon Year-class Strength (Survey 7), which uses baited hooks— tow nets of varied configurations to target fishes during their first year of life. Several surveys, such as the Bay Study, Fall Midwater Trawl, Spring Kodiak and Suisun Marsh Fish Community, are also effective capturing older age groups. Only a one survey samples shoreline fishes using a stratified random sampling scheme (Survey 10, Table 2.1). This survey captures fishes of multiple ages using boat electrofishing. Four surveys sample at single locations repeatedly within sampling days year-round (Surveys 11-14, Table 2.1). These surveys also capture predominantly age-0 fishes, but all catch some older age groups, particularly Chipps Island and the CVP and SWP Salvage surveys. Finally, two surveys are somewhat flexible in their sampling locations, fishing for about two months in survey years and targeting adult white sturgeon or legal-sized (≥ 18”) striped bass (Surveys 15-16, Table 2.1). These surveys use mark-recapture techniques to estimate absolute abundance of both species and annual mortality rate of white sturgeon.

Each of the 16 surveys can calculate current or projected abundance indices for its target species. The first 10 also provide general information on the distribution of target species.

**Table 2.1. Basic Information and Program Element Description[2].**

| Program | Agency | Mandate Information | Design | Years Surveyed | Months | Survey Interval | Gear |
|---|---|---|---|---|---|---|---|
| **Survey Group 1: Multiple, Fixed Location Sampling** | | | | | | | |
| 1. Beach Seine | FWS | "Soft" mandate in NOAA OCAP as part of Oct-May RTM | Systematic | 1976 to present | All | Weekly | Beach Seine |
| 2. Bay Study | DFG | "Soft" mandate in water rights decision D 1641 | Systematic | 1980 to present | All | Monthly | Otter Trawl, Midwater Trawl |
| 3. Fall Midwater Trawl | DFG | Spring 2004 OCAP for delta smelt | Systematic | 1967 to present (no data 1974, 1979) | Sep-Dec | Monthly | Midwater Trawl |
| 4. Summer Townet | DFG | Spring 2004 OCAP for delta smelt | Systematic | 1959 to present (no data 1966; no striped bass index 1995 or 2002) | Jun-Aug | 2 weeks | Townet |
| 5. 20 mm Survey | DFG | Spring 2004 OCAP for delta smelt | Systematic | 1995 to present | Mar-Jul | 2 weeks | 20 mm |
| 6. Spring Kodiak Trawl | DFG | Spring 2004 OCAP for delta smelt | Systematic | 2002 to present | Jan-Apr | 2 weeks | Kodiak Trawl |
| 7. Juvenile Sturgeon | DFG | Not mandated | Systematic | 1991 to present (no data 1992, 1993, 1994, or 2003) | Jun-Aug | Monthly | Long-line |
| 8. Suisun Marsh | UCD | "Soft" mandate in D 1641 | Systematic | 1980 to present | All | Monthly | Otter Trawl, Beach Seine |

[2] **The IEP website contains additional information about survey elements at: http://www.iep.ca.gov/geninfo1.html, http://www.iep.ca.gov/geninfo2.html, http://www.iep.ca.gov/geninfo3.html, and http://www.iep.ca.gov/geninfo4.html.**

| Program | Agency | Mandate Information | Design | Years Surveyed | Months | Survey Interval | Gear |
|---|---|---|---|---|---|---|---|
| 9. North Bay Aqueduct | DFG | Pilot study for a broad, within-delta larva survey is mandated in the spring 2004 OCAP for delta smelt | Systematic | 1995 to 2004 | Feb-Jul | 2-4 days | Plankton Net |
| **Survey Group 2: Fixed Regional Strata, Random Location** | | | | | | | |
| 10. Resident Fishes | DFG | Not mandated | Stratified | 1995, 1997, 1999, 2001-present | All | Monthly | Boat Electrofishing |
| **Survey Group 3: Single, Fixed Location Sampling** | | | | | | | |
| 11. SWP and CVP Fish Salvage | DFG in conjunction with DWR and USBR | Spring 2004 OCAP for delta smelt | Temporally Systematic | 1979 to 1992 involved less comprehensive sampling compared to post-1992 to present | All | Daily from as frequent as hourly counts | Screened Louvers and Holding Tanks |
| 12. Chipps Island Trawl | FWS | "Soft" mandate in NOAA OCAP as part of Oct-May RTM | Temporally Systematic | 1976 to present | All | 2-3 days (daily May-June) | Midwater Trawl |
| 13-14. Sacramento River and Mossdale Trawls | FWS | "Soft" mandate in NOAA OCAP as part of Oct-May RTM | Temporally Systematic | 1976 to present (no data 1982 to 1987) | All (M) | 2-3 days | Midwater Trawl, Kodiak Trawl |
| **Survey Group 4: Flexible Location Sampling** | | | | | | | |
| 15. Adult Sturgeon Tagging | DFG | Not mandated | Mark Recapture | 1967,1968, 1974, 1979, 1984, 1985, 1987, 1990, 1997, 1998, 2001, 2002 | Sep-Oct | opportunistically (San Pablo Bay) | Trammel Net |
| 16. Adult Striped Bass Tagging | DFG | Not mandated | Mark Recapture | 1969 to present (no data 1995, 1997, 1999, 2001) | Apr-May tagging & some recovery; Creel Check All | Annual 1969-1994, 2003+;Biannual 1995-2002 | Gill Net, Fyke Traps and Creel Check |

## 2.2. Sampling methods and gear

The **USFWS Beach Seine Survey** uses a 15m long by 1.2 m high seine with 1/8" delta mesh set from shore to capture fishes from water generally ≤1m deep. Two technicians deploy the seine over a roughly rectangular area and record maximum depth and dimensions of the area swept (**Figure at right**, the seine is being hauled to shore). Single seine hauls are conducted weekly year-round at each of 57 current sampling locations that range from Central San Francisco Bay upstream into the lower Sacramento and San Joaquin rivers. The survey requires 2 technicians, a truck or small boat and 6-7 days a week to complete. All fishes ≥ 25 mm (with some exceptions) and some shrimp and crabs are identified to species and enumerated; all salmonids and up to 50 of each other fish species are measured to the nearest mm fork-length or total length. All organisms are returned to the water except fin clipped salmon. See Appendix B.1 for more details.

The **Bay Study Survey** employs the 42 foot Research Vessel Longfin to fish a midwater trawl and an otter trawl monthly year-round at each of 52 open-water sampling locations. Sampling locations range from southern South San Francisco Bay, through San Pablo and Suisun Bays and into the Delta. The survey takes a 4-5 person crew seven days to complete. The midwater trawl, has a 3.7 $m^2$ mouth and meshes that graduate from 20.3 cm at the mouth to 1.3 cm at the cod end. The midwater trawl is towed with the current for 12 min and retrieved obliquely, sampling the water column from bottom to surface. The volume filtered is calculated as the product of the mouth area under tension (10.7 $m^2$) and the distance traveled as measured by a flow meter. The otter trawl has a 4.9-m headrope, a 2.5-cm stretch mesh body and a 1.3-cm woven mesh cod end. This trawl is towed against the current for 5 min on the bottom. Area swept by the trawl is calculated as the product of the door spread under tension (3.4 m) and the distance towed estimated by Loran C or GPS, converted to meters (**Figure above**: the last of the otter trawl is being pulled onboard). All fish and Cancer crabs are identified to species, enumerated and up to 50 fish and 30 crab of each species are measured (crabs are also sexed) before being returned to the water. Jellyfish are counted and returned to the water and shrimp are preserved and returned to the lab for identification and measurements. See Appendix B.2 for more details.

The **Fall Midwater Trawl Survey** can be conducted from one of several Research Vessels, primarily Scrutiny (32'), Munson (25'), or New Alosa (42'). The survey sets a midwater trawl at 116 locations once monthly from September through

December and takes a crew of three eight days to complete. Sampling locations range from San Pablo Bay upstream through Suisun Marsh and Bay and into the Delta as well as the lower Sacramento and San Joaquin rivers. The FMWT uses same trawl design and 12 min oblique tow as the Bay Study (**Figure at right:** trawl retrieve almost complete; back deck of Scrutiny). Fish, shrimp and jellyfish are identified to species and enumerated. Up to 50 fish of each species are measured to nearest mm fork-length (or total length). Although a flow meter is currently placed in the water for each tow and volume filtered can be estimated, fish densities are reported in catch per tow. See Appendix B.3 for more details.

The **Summer Townet Survey** can also be conducted from one of several Research Vessels, primarily the Munson (25'), Scrutiny (31') or New Alosa (42'). A three-person crew can complete the 32 location sampling schedule in five days. Sampling locations range from eastern San Pablo Bay upstream through Suisun Bay and Marsh and into the Delta including the lower Sacramento and San Joaquin rivers. This survey runs every other week from early June through late August and uses a 4.3 m long net attached to a skid mounted frame and possessing a 1.5 $m^2$ mouth, a 2.1 m body of 20 mm woven mesh and a 2.1 m cod end of 4 mm woven mesh (**Figure at right**: the townet is being brought back aboard the New Alosa). At each location up to three oblique 10 min tow are made (only two tows are made if no fish are caught). All fish are identified to species and enumerated, and a subset measured to the nearest mm fork length. This survey currently runs on alternate weeks to the 20mm Survey during June and July. See Appendix B.4 for historical differences and more details.

The **20 mm Survey** is generally conducted from either the Scrutiny (31') or the Munson (25'). It takes a three person crew six days to sample the 41 survey locations (46 in a wet year); a process conducted every other week from late March through July. Sampling locations range from eastern San Pablo Bay, through Suisun Bay and Marsh and throughout the Delta (**Figure at right**, clockwise from top: Munson towing 20mm net; ichthyo-samples prior to return to the lab; mouth-view of 20mm net, with zooplankton net on top; measuring water temperature and electrical conductivity). Three 10-min oblique tows are conducted at each location using a 5.1-m long, skid mounted net with a 1.5 $m^2$ mouth, a 1.6 mm mesh body and a removable 2.2 L cod end jar. After each tow, cod end jar contents are preserved, labeled and returned to the lab for identification. Volume filtered is

determined from readings of a flow meter suspended in the net mouth and mouth area. See Appendix B.5 for more details.

The **Spring Kodiak Trawl Survey** requires two boats, usually the Scrutiny (31') and a Kvichak (24'), a crew of four, and 4-5 days to cover the 39 sampling locations once monthly from late January though mid-May. A second sampling scheme, conducted monthly two weeks after the first, focuses 1-2 days of sampling in regions of high delta smelt density to gather more information on gonad maturity. The 39 primary sampling locations are distributed from Napa River and Carquinez Strait, through Suisun Bay and Marsh, and throughout the Delta (**Figure at right**: Kodiak trawl underway looking astern from the Scrutiny flying bridge; orange floats mark the net end; the second boat is out of view to the left). At each location a single, 10 min surface tow is made using a 7.6 m wide by 1.8 m high Kodiak trawl, which tapers to 6 mm mesh. The net is retrieved to the larger vessel and brought on board, then both vessels travel to the next location while the fish caught are identified, enumerated, measured to the nearest mm fork-length and released, except for delta smelt which are preserved and returned to the lab for gonad staging. See Appendix B.6 for more information.

The **Juvenile Sturgeon Survey** requires only a single vessel from 24' to 31' and a crew of three to sample approximately 21 locations during a two week period monthly from June through August. Sampling locations range from eastern San Pablo Bay, through Suisun Bay into the western Delta. At each location, baited setlines are fished for approximately 24 hrs targeting age 1-7 (juvenile) sturgeon using lamprey, threadfin shad, mud shrimp, ghost shrimp, bay shrimp and pickled squid as bait. Each setline includes an 1800-ft ground tackle with approximately 100 gangions attached. Each gangion includes a halibut snap, a 3-foot leader, and a single baited hook. Up to four lines are fished at a time. See Appendix B.7 for more information.

The **Suisun Marsh Survey** uses a dedicated vessel to sample monthly year-round at 21 slough locations with an otter trawl and at two shoreline locations with a beach seine; all sampling locations are in Suisun Marsh. This sampling takes a two person crew about 4 days. At each slough location two otter trawl tows are made using 5.3 m long by 2.5 m head rope trawl with a 35 mm mesh body and 6 mm

mesh cod end towed on the bottom at about 4 km/hr for 5 min. Seine hauls are conducted from shore at two locations using a 10 m net. Organism abundance is expressed as catch per tow or haul. Fishes from all samples are identified to species, enumerated and measured to the nearest mm standard length before being returned to the water. Macro-invertebrates are identified and enumerated (mysids are given abundance rankings); Chinese mitten crabs are sexed and measured to the nearest mm maximum carapace width. See Appendix B8 for additional information and other parameters measured.

The **North Bay Aquaduct Survey** (presented schedule terminated in 2004) used primarily the Research Vessel Beowulf (25') to sample at either four (every two days) or all eight (every four days) survey locations in the north Delta. A crew of three conducted a single oblique ichthyoplankton tow at each location on survey dates beginning February 15 and ending July 15 using a 3.4-m long, skid mounted net composed of 505 micron mesh nylon with a mouth area of 0.37 $m^2$. This resulted in 15 - 16 field days per month during the survey period. A flow meter mounted in the net mouth and the mouth area allowed calculation of volume filtered. Organisms captured were preserved and returned to the lab for identification. See Appendix B.9 for more information.

The **Resident Fishes Survey** uses an 18' Smith Root Electrofishing boat and a crew of two to sample monthly year-round at 20 randomly selected 500 m reaches of shore-line (<4 m deep) spread across five regions, all within the Delta. The survey takes about 10 field days a month to complete. Sampling consists of the boat moving systematically down the shoreline, re-orienting perpendicular to shore, then completing the circuit, whereupon fish within the created electrical field are attracted to the forward mounted anode probes (**Figure above**). Stunned fish netted by the technician in the bow are transferred to a live well until sampling at the current reach is completed, at which time they're identified, enumerated and measured to the nearest mm fork length, then released. Effort is determined by the number of "shocking seconds" expended sampling the reach. In spring approximately 400 largemouth bass are tagged annually to investigate angler harvest rate. See Appendix B.10 for more information.

The **Central Valley Project** and the **State Water Project** are located in the southern delta and currently each exports water from a single location. Both employ louvered screens across their water intake channels to guide fish out of the export water stream and into a bypass system from which they will be collected and trucked back to the western

Delta. The louvers guide fish whenever water is being pumped (**Figures at right. CVP top, SWP bottom**) and counts are made periodically throughout each day of pumping, which requires on average three persons per day (one for each shift) per facility. The number of fish and crabs salvaged by these systems is estimated by periodically counting organisms from a known proportion of the bypassed flow and scaling up. For example the number of organisms from 20 min of sampled flow over a two hour interval would be multiplied six times to estimate total salvage. Both facilities identify and enumerate all fish collected >20 mm fork length and measure a subset of each species. See Appendix B.11 for more information.

The **Chipps Island Trawl Survey** uses the Research Vessel Whitesel (40') and a crew of three to sample every 2-3 days year-round adjacent to Chipps Island at the confluence of the Sacramento and San Joaquin rivers. On each sampling day 10 surface tows are made using a midwater trawl with a mouth 9.1 m wide by 3.0 m tall and meshes that graduate from 10 cm at mouth to 0.8 cm at the cod end. Tows alternate among three trawling lanes in the north, south and middle of the channel. Fishes captured ≥ 25 mm fork length (with some exceptions) and macro-invertebrates are identified and enumerated. All Chinook salmon and a subset of each other fish species are measured to the nearest mm fork length and all are returned to the water, except Chinook salmon possessing an adipose fin clip, which are retained for later recovery and reading of an embedded coded wire tag. Volume filtered is estimated based on flow meter readings and knowledge of the net mouth area during towing. See Appendix B12 for additional information.

The **Sacramento and Mossdale Trawl surveys** employ either one (Sacramento only) or two vessels depending upon the trawl used. Two vessels (27' and 23') and a total crew of four are used when a Kodiak Trawl is towed -- October through March at Sacramento and year-round at Mossdale. Only a single vessel (27') and a crew of three are used when a midwater trawl is towed –April through September at Sacramento (**Figure at right**). Regardless of net used, 10 surface tows are made 3 days per week, year round. Sampling is increased during important migration periods. The Kodiak trawl has a mouth 7.6m wide by 1.8 m tall and meshes graduated from 5cm at the mouth to 0.6 cm at the cod end followed by a live box. The

midwater trawl has a mouth 4.6 m wide and 1.8 m tall with mesh size graduated from 20 cm at mouth to 0.6 cm at the cod end. Fishes captured ≥ 25 mm fork length (with some exceptions) and macro-invertebrates are identified and enumerated. All Chinook salmon and a subset of each other fish species are measured to the nearest mm fork length and all are returned to the water, except Chinook salmon possessing an adipose fin clip, which are retained for later recovery and reading of an embedded coded wire tag. Volume filtered is estimated based on flow meter readings and knowledge of the net mouth area during towing. See Appendix B13 and B14 for additional information.

The **Adult Sturgeon Survey** uses one of two research vessels equipped with a net reel to safely and efficiently deploy and retrieve the long trammel nets: the Striper II (32') and the New Alosa (42'). Field sampling occurs for two years in a row then skips two years. During survey years, a single crew of 3-4 persons works five days a week for the months of September and October setting a net in regions of San Pablo Bays where capture of white sturgeon is likely. Some August sampling occurred recently to gather information on green sturgeon. A 200 fathom (1200') by 2 fathom deep trammel net is deployed, drifted with the current for a short period of time then retrieved; a set -- including 10 min to lay out, drift fishing and retrieval -- can take up to an hour. The four 50 fathom, 3-layer panels are composed of 6, 7or 8" stretch mesh inner layer, sandwiched between outer layers of 24, 28 and 32" mesh, respectively. All legal sized white sturgeon (46-72") are measured (nearest cm total length), uniquely tagged – including systematic inclusion of reward tags – and released after collection of a fin ray to determine age. All others and green sturgeon are measured and released. Other species are only identified and enumerated. Capture of previously tagged fish is recorded as part of the data used to calculate population size. See Appendix B15 for more information.

The **Adult Striped Bass Survey** sets drift gill nets and large fyke traps during the spring spawning migration to capture striped bass ≥18" for tagging and for recovery of previously tagged fish. Tagging occurs and has occurred annually except for a brief period in the mid to late 1990s when it occurred every other year. To tag striped bass, two research vessels equipped with net reels (the Striper II (32'), Splittail (25') or New Alosa (42')) deploy 600' drift gill nets (4, 4.5, 5 and 5.5" stretch mesh) near the confluence of the Sacramento and San Joaquin rivers 5 days/week during April and May of tagging years; also, 12 fyke traps are fished daily, April – May in the vicinity of Knights Landing on the Sacramento River. The 10'-diameter by 20'-long

fyke traps are covered in 2" square mesh, 11 gauge galvanized chain link fencing material with 2" square mesh polyethylene netting covering the two throats and one end of the traps. All legal sized (≥18" total length) striped bass captured are uniquely tagged – including systematic inclusion of reward tags – measured, sexed and have scales removed before release. All tagged fish are aged from annuli counts on scales. Mark-recapture population estimates are stratified by sex and age to determine factors affecting bass abundance and survival and current population status. Other fish captured by both gears are identified and counted, but are not included in the data base. See Appendix B16 for more information.

## 3. General Highlights

The following bullets present major findings from questionnaire responses, divided by sections and themes in this report. For more comprehensive discussion of results, please read the full summary of the sections and review the original survey responses in Appendix B.

Basic Information and Program Element Description

- The most common sampling design for sampling "Multiple, Fixed Location" (9 surveys). The other sampling designs were: "Fixed Strata, Random Location" (1 survey); "Single, Fixed Location" (4 surveys, Salvage combined); and "Flexible Location" (2 surveys).
- DFG conducts most of the surveys, followed by FWS.
- Survey intervals ranged from daily to annual.
- Surveys ranged from 3 to 12 months in duration.
- Gear type varies substantially throughout the program. The only shared gear types are midwater trawls (4 surveys), otter trawls (2 surveys) and beach seines (2 surveys), louvered fish screens (2 surveys).

Budgets, Staffing, and Resources

- Collaboration among the surveys occurs between agencies (primarily DFG and FWS boat operators and vessels) and among surveys within agencies (DFG and FWS Biologists can lead several surveys each).

Progress Toward IEP Goals

- Five surveys (Fall Midwater Trawl, Townet Survey, Spring Kodiak Trawl, 20 mm Survey and SWP/CVP Salvage) are required fish monitoring elements under the USFWS 2004 OCAP Biological Opinion. Four additional surveys (Beach Seine, Chipps Island, Sacramento Trawl, Mossdale Trawl) received a "soft" mandate as part of a real-time monitoring requirement in the 2004 Biological Opinion from NOAA Fisheries.
- Surveys mostly address the goal of monitoring the distribution and abundance of special status species, sport fishes, forage fishes, and invasive species.
- Predictably, the surveys mostly do not address the goals of monitoring water quality, hydraulics, lower trophic levels, or benthic organisms.

- Most surveys reported that they are trying to meet IEP's goal of determining the relationships between variables monitored by IEP.
- Most also reported that their program monitors how fish abundance and distribution are affected by water project operations, use of environmental water and ecosystem restoration. Agricultural diversions are not directly being addressed by any of the surveys.

Strengths for Determining Status and Trends of Fishes

- Most surveys have long, consistent historical data sets
- Several rapidly make data available, providing near real-time dissemination via the internet.
- Over half the surveys sample open water in channel and shoal habitats >2m deep.
- Three surveys sample entrance and exit points of the Delta for age-0 anadromous fish.
- Six surveys provide broad geographic coverage; as a whole, sampling covers all CBDA regions in the Estuary and Delta and extends into the lower Sacramento and San Joaquin Rivers
- Most surveys exhibit substantial integration of field personnel and sharing of resources, boats, lab space, and equipment.
- Twelve surveys most effectively target age-0 fish and use information to assess relative year-class strength.
- Sampling and data collection for 12 surveys are now focused on multiple species and away from emphasizing single species.

Rapid data availability and multiple species focus have led to more intensive data use in water management decisions, species research and species status reviews: 1) Delta smelt catch data from Spring Kodiak Trawl, 20mm Survey, Townet Survey as well as Chinook salmon catch data from Sacramento, Mossdale and Chipps Island Trawl surveys and the Beach Seine Survey and both species numbers in Salvage surveys are used to make real-time decisions on Delta Cross Channel gate closures (in the case of Chinook salmon catches), on water export rates and use of Environmental Water Account assets; 2) striped bass data from Townet, Fall Midwater Trawl, Bay Study otter trawl, and Salvage have been used at different times to investigate the population dynamics of age-0 fish; 3) splittail abundance and distribution data from seven different IEP Fish surveys were used to investigate species status and need for listing. Some of these data also support traditional DFG needs to monitor sport fish population status (e.g., sturgeon and striped bass) and develop appropriate fishing regulations.

Weaknesses for Determining Status and Trends of Fishes

- Five surveys sampling at single locations and two geographically limited surveys are susceptible to interpreting a shift in fish distribution as a change in abundance.
- Few surveys target larval (1) or adult (2-3) fishes due to effort and expense.
- Only 3 surveys target or effectively sample off-channel habitat (i.e. <2m deep shoals, marshes, floodplains), particularly those with vegetation or hard structure.
- Only 2 surveys attempt calculation of population size (Adult Sturgeon and Adult Striped Bass); most trawl surveys lack information on gear efficiency necessary to begin the process.

- Most surveys don't attempt to quantify variability in data used for abundance index calculation (i.e., no estimate of precision of abundance index), which confounds natural variability and what we can reasonably do with the data.

Continually Assess and Improve Program Elements to Support Management Priorities

- Eight surveys report proposing or conducting field or analytical studies to assess current or new sampling methods.
- Eleven of 16 surveys reported some effort to review and improve monitoring element processes, and 8 listed quality control and quality assurance examples.
- Nine projects reported using historic information to change program element design or suspected that current analyses might result in a future design change.
- One survey was recently implemented (Spring Kodiak Trawl in 2002) to improve distributional information on mature delta smelt and another (North Bay Aqueduct) will be modified in 2005 to improve larval delta smelt distributional information, both in response to management needs for information.

Data Products, Availability, and Reporting

- Data are publicly available for all but readily available for 81% (13 of 16) of the fish monitoring program elements. Nearly 70% (9 of 16) of these program elements use the Bay-Delta Tributaries Database (BDAT) as the public data repository; data for the remaining surveys are available through their lead biologist.
- 75% (12 of 16) of the fish monitoring program elements have some level of web page reporting. Six program elements use web-based reporting extensively to disseminate data and summary information in near real-time.
- Between 1994 and 2003, IEP Newsletter articles were the major form of written communication produced (mean = 7.2 articles/program element) followed by peer-reviewed journal articles (mean = 2.8 articles/program element). Only 25% (4 of 16) of the fish monitoring program elements have used technical reports as a means for written reporting during the last ten years.
- Species-specific information was the most common topic of written communications followed by status and trends reporting.
- On average, the same number of "other products" was produced as peer-reviewed journal articles. Other products, includes written reports and popular articles, oral and poster presentations, theses and dissertations, and workshop summaries.
- Staff from all fish monitoring program elements plan on producing several written and oral products between 2004 and 2007 (mean = 5.1 products/program element). Most commonly sited products were journal articles or IEP Newsletter articles.

Customer Needs and Use

- Questionnaire responses generally report that customers are very satisfied with the quality of the monitoring data; responses ranged from no complaints to positive feedback.

- The most valuable aspect of many surveys is the longevity, combined with temporal and spatial consistency of the sampling.
- The types of customer use most frequently cited in questionnaire responses include environmental documentation, project analysis, regulatory, and research applications.
- The geographically broad to narrow systematic sampling range program elements (Group 1) frequently serve all customer types: IEP, CALFED, sport fish, and regulatory agencies, as well as other government, academic, NGO, and consultant entities.
- The relatively broad stratified random survey (Group 2) serves IEP agencies and sport fish management entities interested in long-term abundance distribution trends and life history information.
- Single-location, temporally systematic sampling program elements (Group 3) convey information to IEP, CALFED, and regulatory agencies, as well government, academic, NGO, and consultant entities with a focus on environmental documentation.
- The flexible location sampling (Group 4) primarily serves IEP, sport fish management, and regulatory agencies (particularly those interested in long time-series fish population data) as primary customers, with academics and research-focused NGOs serving as additional customers.

Recommended Actions

- Most elements reported that new, alternative, or more frequent analytical work is appropriate.
- Staff of elements monitoring status of juvenile and adult non-salmonid sport fishes reported that technical reports are necessary to evaluate and improve element effectiveness and efficiency

## 4. Budgets, Staffing, and Resources

The following is a synopsis of staffing and budget information provided in element questionnaires and/or from IEP planning data. Budget data presented here for DFG Fish Surveys may differ from those presented in the questionnaires: our data reflect a complete cost accounting for field and lab personnel that has not been captured previously and includes higher benefit and overhead rates than were used by most survey respondents.

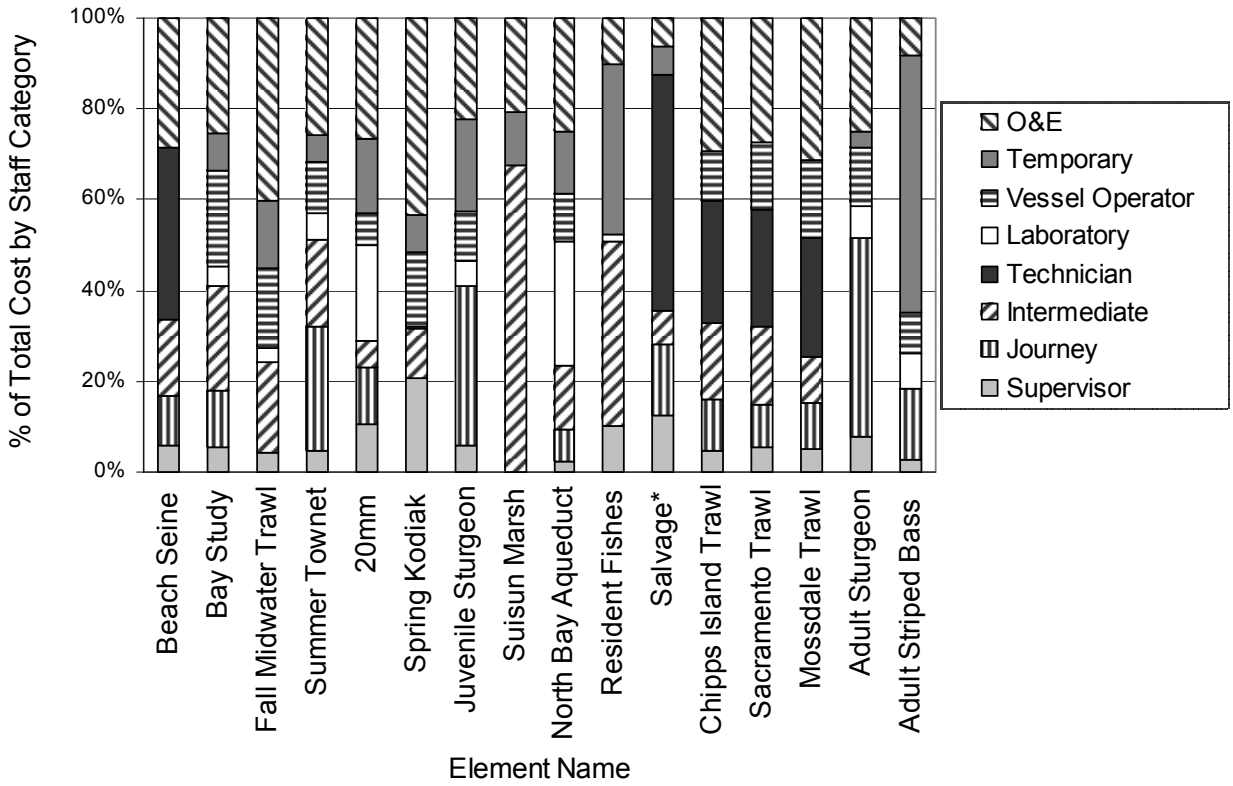
To develop costs by staff level, personnel were categorized and dollar amounts for each category augmented to account for benefits and overhead at the 2004 level. Operations and equipment costs were also augmented to account for overhead. Budgets included all funding sources for each program element. Categories were filled across agencies as follows: **Supervisor** – GS-12 Biologist, Senior Biologist and Professor; **Journey** – GS-11 Biologist and Associate Biologist; **Intermediate** – GS 9 Biologist, Assistant Biologist and Graduate Researcher; **Technician** – GS 5-7 Biological Science Technicians, USBR Technicians; **Laboratory** – Laboratory Assistant, Senior Lab. Asst., Supervising Lab. Asst. and contracted Lab Technicians; **Vessel Operators** – WG 9 Small Craft Operators, F&W Technicians (DFG) and Mates; **Temporary** – F&W Scientific Aids, Office Technicians and Key Punch Operators.

Some budget and staff effort data were omitted from questionnaire responses and not obtained afterwards in time to be included in this report. Omissions include costs associated with Supervision of the Suisun Marsh Survey – although they were estimated very roughly – and costs and effort associated with DWR's portion of fish salvage. No adjustments were made to compensate for these omissions in most results; however, a proportional estimate of IEP vs non-IEP funding of the Suisun Marsh Survey was included based upon an email.

To assess how surveys allocated staff effort, personnel time (days) for all classifications was tallied into task categories, such as field work, lab work, and analysis/writing etc, by questionnaire respondents assuming 20 work days per month. We summed results by task category to provide total day estimates for each task category. For our summaries all vessel maintenance time was allocated to field work and web page work combined with data analysis/report writing. The overhead category captured time not otherwise allocated including training and meetings, and staff supported but not directly participating in the survey (e.g., on disability or sick leave, office support staff). Finally, we present IEP funding as a proportion of total survey funding.

Costs and proportion of total cost by staff category varied considerably across surveys and were strongly influenced by the fish life stage targeted and by how each survey assigned staff duties, which varied by lead agency (Figure 4.1). Use of laboratory personnel was low or non-existent unless larvae or small fishes were commonly returned for identification (e.g., Bay Study, Townet, 20 mm, North Bay Aquaduct) or fish aging and tagging data processing was routinely conducted (e.g., Adult Sturgeon and Adult Striped Bass). Technicians were used differently across surveys. The four USFWS surveys and the Salvage Surveys used Technicians as field lead persons – DFG and Suisun Marsh surveys used Intermediate or Journey level Biologists as field lead persons – whereas DFG personnel classified as technicians were used as and categorized as either Vessel Operators or Laboratory staff based on duties (Figure 4.1). Temporary help was used to varying degrees by all surveys except the four run by USFWS, which because of year-round sampling were run entirely by permanent personnel. Temporary personnel were particularly important to the Resident Fishes and Adult Striped Bass surveys, both year-round surveys, where they conducted the majority of the field sampling and all the angler creel surveys to gather striped bass harvest data, respectively (Figure 4.1). The proportion of cost accounted for by biological staff categories reflects both the size of the survey staff and to a lesser degree the biological staff splitting time across surveys: DFG and FWS Supervisors all split time across surveys, and this was an uncommon occurrence for Journey and Intermediate biologists.

**Figure 4.1. Percent of Costs by Staff Category in each Survey.**




The total survey budgets were positively related to the frequency and annual duration of sampling and secondarily to the need for processing samples in the laboratory (Table 4.1). Year-round surveys (Beach Seine, Bay Study, Salvage, Chipps Island, Sacramento Trawl and Mossdale Trawl) or those with a year-round component, such as creel census for Adult Striped Bass, were relatively expensive and somewhat similar to one-another in total budget (Table 4.1). Two exceptions, the Suisun Marsh and Resident Fishes surveys, were both run year-round on very limited budgets, using well trained student volunteers or temporary help for tasks completed by permanent staff on other surveys. Additional savings for the Suisun Marsh Survey resulted from UC Davis paying for supervision costs (not disclosed), the Graduate Researcher operating the sampling vessel and extremely low staff benefits (≤1.75% for Graduate Researcher and Student Assistants) compared to other surveys. Salvage was the most expensive survey even without including costs for DWR personnel conducting salvage operations at the State Facility; this cost information was never received (Table 4.1).

The need for laboratory staff and facilities also added to total budgets. Even though the 20 mm Survey ran for about half a year, Laboratory and Temporary staff needs to rapidly identify larval fish and report results increased total costs to the level of year-round surveys (Table 4.1). The North Bay Aquaduct Survey also had considerable Laboratory and associated Temporary help costs, but total budget was held down by limited reporting requirements and nearly automated reporting via the internet, which reduced the need for Biologist and Supervisor time.

Expenditures for Biologists and Supervisors generally reflected actual effort expended on each project, but in a few cases reflected decisions based on ease of budgeting. For example, the Journey and Intermediate Biologists on Summer Townet were similarly funded, thus budgeted together even though the Journey level biologist does analyses for both Townet and Fall Midwater Trawl surveys reviewed here and the previously terminated Striped Bass Egg and Larva Survey, not reviewed (Table 4.1).

**Table 4.1 Costs in dollars by Staff Category for each Survey.** Costs include benefits and overhead for each category. Some source data were incomplete (see asterisks).

| | Expenditure Category | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Survey | Supervisor | Journey | Intermediate | Technician | Laboratory | Vessel Operator | Temporary | Operations & Equipment | Total |
| Beach Seine | 27176 | 49822 | 78438 | 173429 | 0 | 0 | 0 | 131285 | 460150 |
| Bay Study | 27889 | 62029 | 112957 | 0 | 22469 | 104080 | 41331 | 125214 | 495969 |
| Fall Midwater Trawl | 9293 | 0 | 44521 | 0 | 6817 | 39667 | 32594 | 89888 | 222780 |
| Summer Townet | 14008 | 81137 | 56033 | 0 | 16921 | 33564 | 18030 | 75645 | 295340 |
| 20mm | 51179 | 61581 | 30513 | 0 | 102774 | 35645 | 79750 | 131118 | 492560 |
| Spring Kodiak | 37171 | 0 | 19417 | 0 | 810 | 29542 | 14702 | 77490 | 179132 |
| Juvenile Sturgeon | 4230 | 25381 | 0 | 0 | 3883 | 7767 | 14702 | 15990 | 71954 |
| Suisun Marsh* | 0 | 0 | 34059 | 0 | 0 | 0 | 5999 | 10340 | 55798 |
| N. Bay Aqueduct | 4646 | 15395 | 30513 | 0 | 58946 | 22607 | 29126 | 53874 | 215108 |
| Resident Fishes | 14563 | 0 | 58252 | 0 | 2046 | 0 | 53673 | 14760 | 143294 |
| Salvage** | 65430 | 81294 | 39990 | 271932 | 0 | 0 | 33179 | 32265 | 524091 |
| Chipps Island Trawl | 21740 | 49822 | 74733 | 121466 | 0 | 49410 | 0 | 131285 | 448456 |
| Sacramento Trawl | 27176 | 45293 | 81527 | 125790 | 0 | 71645 | 0 | 131285 | 482714 |
| Mossdale Trawl | 21740 | 41896 | 43543 | 111173 | 0 | 72262 | 0 | 131285 | 421900 |
| Adult Sturgeon | 14563 | 80444 | 0 | 0 | 13454 | 23578 | 6519 | 46248 | 184805 |
| Adult Striped Bass | 14563 | 80444 | 0 | 0 | 40901 | 46380 | 295199 | 41701 | 519188 |

* No dollar amount provided for Supervision

** No effort or dollar amount provided for Salvage from DWR.

Reported staff time allocations across tasks varied considerably by survey and didn't always follow dollar allocations. Generally, field work received the largest time allocation (Figure 4.2, Table 4.2). For surveys targeting larval fish (20mm and NBA) or adult fish (Adult Sturgeon and Adult Striped Bass), lab work received the highest or second highest time allocation. Data management occupied a substantial (>10%) fraction of staff time in only 7 of 16 surveys, though some allocating little or no time to this task may have underestimated or accounted for it differently (e.g. Adult Sturgeon and Adult Striped Bass). Data analysis and report writing generally comprised less than 20% of staff time (Figure 4.2, Table 4.2). An extreme exception was the Townet Survey where almost half of the staff time went to analysis and reporting; however, this high proportion complemented the dollar budget and not actual work, which included substantial but unaccounted time for analysis and writing about Fall Midwater Trawl data and about a historical survey that was not part of this review.

Project management generally required less than 10 percent of overall project time, but this time was estimated differently by different respondents (Figure 4.2, Table 4.2). For the Delta smelt projects – Spring Kodiak, 20mm and North Bay Aquaduct – all the Senior Biologist's time was allocated to program management even though considerable time was spent on data analysis, writing and web page management, as well as meetings that might have been considered "other" and summarized into overhead (the "other" category was seldom used by any of the respondents). Supervisor time was similarly allocated, though less time was spent on non-managerial tasks, for Fall Midwater Trawl, Summer Townet, Juvenile Sturgeon, Resident Fishes, Adult Sturgeon and Striped Bass surveys. Alternately, Supervisor-level biologist time spent on Analysis and Writing was reflected in allocations for Bay Study, Beach Seine, Chipps, Sacramento and Mossdale Trawl surveys (See Appendices). Overhead represented a minimal fraction of time except for Bay Study, where much of it resulted from a boat operator expending vacation and sick leave before retirement; thus, the Bay Study budget (Figure 4.1 and Table 4.1) reflected both the staff time needed to conduct the field work plus an additional boat operator on leave.

**Figure 4.2. Percent of Total Days on Task by Survey.** Total staff days per annum are in parentheses. Data are incomplete for Salvage

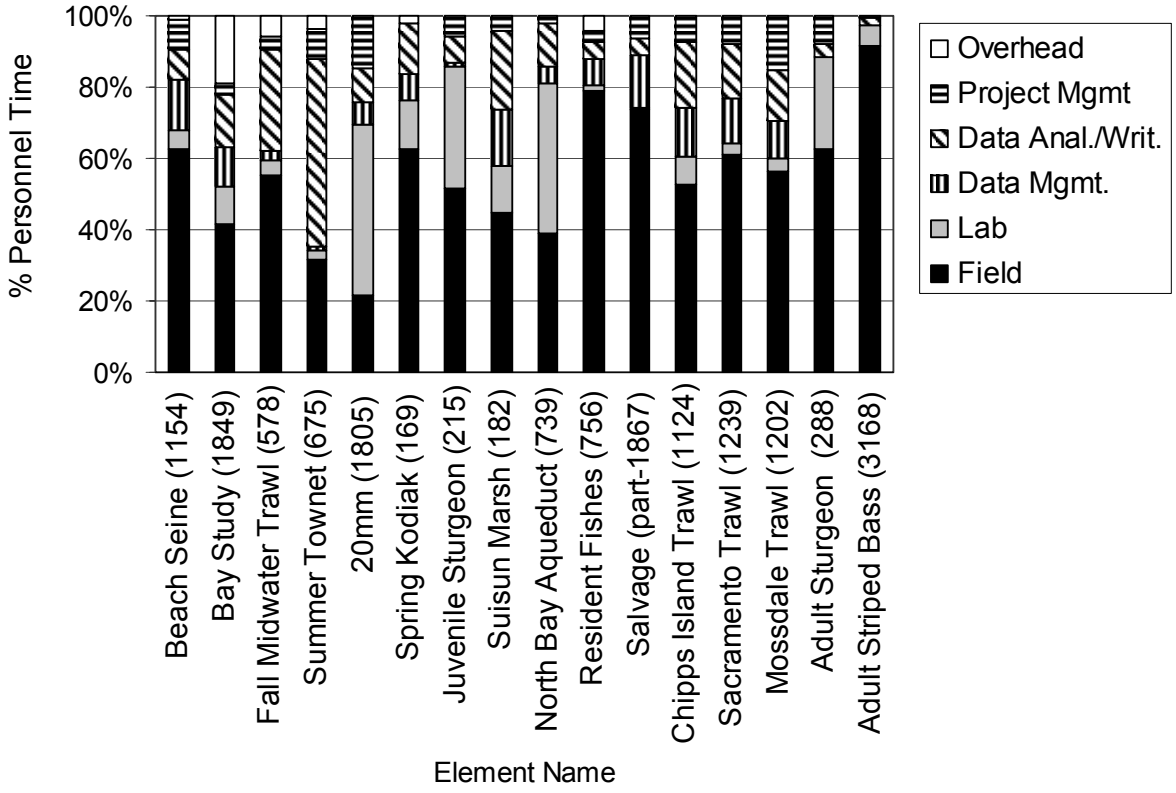
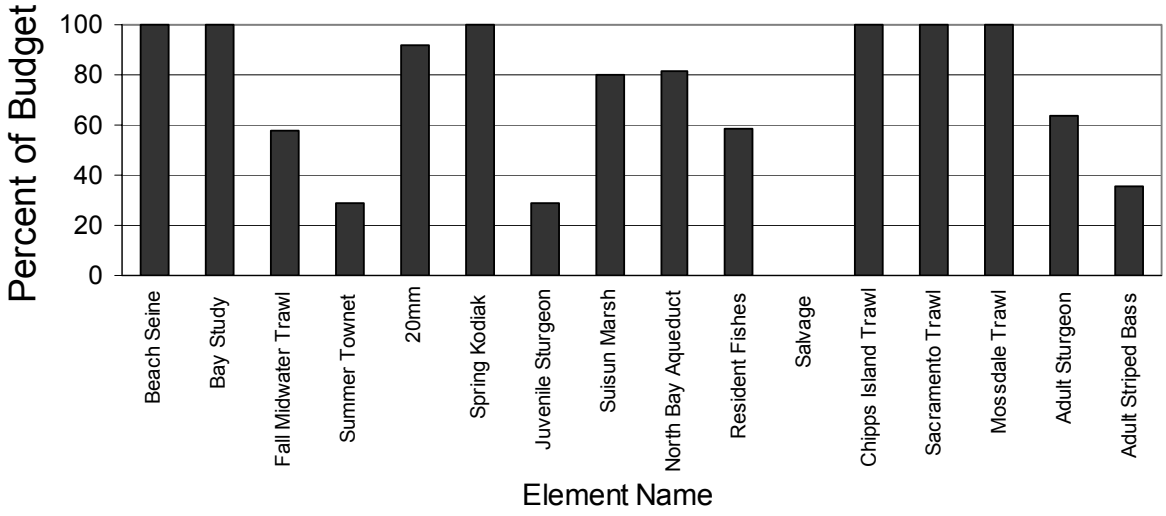


**Table 4.2. Total Days Expended and Total Days on Task by Survey.**

| | Expenditure Category | | | | | | |
|---|---|---|---|---|---|---|---|
| Program Element | Field | Lab | Data Mgmt | Data Analysis and Writing | Project Mgmt | Overhead | Total Days |
| Beach Seine | 722 | 60 | 168 | 96 | 96 | 12 | 1154 |
| Bay Study | 770 | 192 | 201 | 277 | 60 | 349 | 1849 |
| Fall Midwater Trawl | 320 | 24 | 14 | 164 | 24 | 32 | 578 |
| Summer Townet | 212 | 18 | 8 | 354 | 58 | 25 | 675 |
| 20mm | 394 | 864 | 108 | 169 | 270 | 0 | 1805 |
| Spring Kodiak | 106 | 23 | 12 | 24 | 0 | 4 | 169 |
| Juvenile Sturgeon | 111 | 73 | 3 | 16 | 12 | 0 | 215 |
| Suisun Marsh | 120 | 36 | 42 | 59 | 12 | 0 | 182 |
| North Bay Aqueduct | 289 | 309 | 36 | 90 | 15 | 0 | 739 |
| Resident Fishes | 598 | 12 | 55 | 37 | 24 | 30 | 756 |
| Salvage (w/o DWR) | 1378 | 11 | 267 | 91 | 120 | 0 | 1867 |
| Chipps Island Trawl | 590 | 90 | 156 | 204 | 84 | 0 | 1124 |
| Sacramento Trawl | 756 | 39 | 156 | 192 | 96 | 0 | 1239 |
| Mossdale Trawl | 677 | 45 | 126 | 171 | 183 | 0 | 1202 |
| Adult Sturgeon | 180 | 74 | 0 | 11 | 23 | 0 | 288 |
| Adult Striped Bass | 2898 | 182 | 12 | 52 | 24 | 0 | 3168 |

Six of 16 elements were funded exclusively through IEP, one was funded directly by USBR and DWR and nine elements were funded jointly by IEP and DFG (Figure 4.3). Among jointly-funded elements, IEP contributed between 29-91% of the funding. Funds from DFG came from the Striped Bass Stamp Program, the Sportfish Restoration Act and Proposition 50.

**Figure 4.3. IEP Funding as a Percentage of Total Element Budget.**



## 5. Goals, Strengths, and Weaknesses for Determining Status and Trends of Fishes

Information presented in this section complements the summary discussion of the Customer Needs and Use (section 9). Examples of integration are discussed in this section 5, whereas section 9 highlights the applications that result from the program element data and information integration.

### 5.1. Progress Towards IEP Goals

Appendix A presents a list of the most current IEP mission, goals, and objectives statements, as presented to the questionnaire recipients in spring 2004. Table 5.1 shows goals addressed by each survey. The responses generally reflect 2004 survey protocols and may not capture historical methodologies, goals, or targets, some of which have changed over time. A notable exception is new information related to monitoring requirements that are included under a 2004 OCAP Biological Opinions by USFWS and NOAA Fisheries (see below). This information was not available at the time of the survey, but was added by the authors of this report. Additional changes to program requirements, goals and targets will almost certainly occur in future years. Hence, this summary represents a "snapshot" of the progress of each program towards the current priorities.

### 5.2. Introduction and Interpretation Based on Survey Objectives

Of the sixteen surveys, eleven have one or more mandates for their continued operation (Table 2.1). Here we discuss only the most recent mandates, even though some surveys such as CVP and SWP salvage have a long history of mandates: 1) State Water Resources Control Board Decision 1485, 2) NMFS 1993 BO for Sacramento Winter-Run Chinook salmon, 3) 2000 NMFS BO for spring-run Chinook salmon and steelhead, 4) 1986 DWR/DFG Four Pumps Agreement, 5) 2002 DWR/DFG Salvage Operations Agreement, and 6) 2004 USBR/DFG Salvage Monitoring Agreement.

Five fish monitoring elements (Fall Midwater Trawl, Townet Survey, Spring Kodiak Trawl, 20 mm Survey, and SWP and CVP Salvage) are required under the 2004 OCAP Biological Opinion, which USFWS issued for the operation of the state and federal water projects. These monitoring elements are required parts of the project description of the CVP and SWP to help minimize take of delta smelt. Although the North Bay Aqueduct survey was required under the 1995 OCAP Biological Opinion, the survey is scheduled to be replaced in 2005 by a Delta-wide larva sampling pilot effort, with resultant gear and protocols incorporated into an expanded 20 mm survey.

NOAA Fisheries 2004 OCAP Biological Opinion for Chinook salmon and steelhead trout was not as explicit as that of the USFWS. Under its terms and conditions the NOAA OCAP requires that " Reclamation and DWR shall continue the real-time monitoring of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead in the lower Sacramento River, the lower San Joaquin River and the Delta…" and "…continuous real-time monitoring must be conducted between October 1 and May 31 of each year commencing in 2004." Although not specifically identified, the four USFWS surveys (Beach Seine, Sacramento, Mossdale and Chipps Island Trawl Surveys) all target the salmonids in question and provide the required data, so are in a sense mandated.

Most surveys report that they contribute to resource management goals of determining the relationships between fish populations and environmental variables monitored by IEP. In particular, surveys monitor environmental trends in conjunction with special status species (e.g., delta smelt, splittail, salmonids) and sport fish species (e.g., sturgeon, striped bass, and American shad, catfish). Predictably, the surveys mostly do NOT address the goals of monitoring water quality, hydraulics, lower trophic levels or benthic organisms. Exceptions include conductivity, water temperature and Secchi depth taken by most surveys, dissolved oxygen measurements recently implemented by Suisun Marsh, plankton sampling in conjunction with 20mm sampling, identification and enumeration of jelly fishes (Bay Study and FMWT), shrimps (Bay Study, Suisun Marsh, FMWT, and FWS Seine), *Cancer* crabs (Bay Study), and the Chinese mitten crab (Bay Study, Suisun Marsh, SWP and CVP salvage, and FWS Seine).

Most also reported that their program monitors how fish abundance and distribution is affected by water project operations, use of environmental water and ecosystem restoration. Effects on fish of Agricultural diversions are not directly addressed by any of the surveys.

All 16 long-term fish monitoring surveys were established with goals for monitoring abundance or distribution trends of a particular species or group of species, except fish counts made at the fish salvage facilities. Salvage counts were originally intended to quantify fish saved from entrainment and returned to the Delta, initially for striped bass and Chinook salmon; however, they represent some of the largest annual collections of several species of concern, including winter-run Chinook salmon, delta smelt and splittail, among IEP surveys. Salvage counts have proven useful to both scientists investigating abundance trends and managers investigating potential water export effects on fisheries. For these reasons, salvage counts—or more specifically salvage rates—have been incorporated into IEP long-term monitoring.

Based upon species and habitat sampling goals, different sampling strategies are used for migratory and resident species. Although all fishes move in search of food, some also change habitats seasonally or ontogenically. Some sampling designs take advantage of these movements to census individuals. For example, the open water surveys take advantage of the ontogenetic movements from shallow to deeper waters of many of the transient species. Seasonal trawling at Chipps Island, Sacramento River and Mossdale takes advantage of known Chinook salmon and steelhead migratory patterns to capture juveniles that must pass to reach the ocean. Repeated trawling at single locations allows these surveys to index the total number of juveniles emigrating in a year.

In the sections immediately following we group the surveys by general sampling strategy, discuss the limitations of each sampling strategy to address questions related to trends in abundance and distribution, and present results of the effectiveness of each survey in capturing species.

**Table 5.1. Goals Addressed by Each Survey.** Programs indicated with an asterisk are required under the USFWS 2004 OCAP Biological Opinion. See text for details and Customer Needs and Use (section 9) for applications.

| Program | **Goal 1.1:** Determine the trends in environmental variables and trends in the distribution and abundance of living resources | **Goal 1.2:** Continually assess and improve the long-term monitoring program elements to support management priorities (e.g. new variables, methods) | **Goal 2.1:** Determine interrelationships among monitored variables (e.g. effects of hydraulics on early life stages of special status fish species, food web structure and function). | **Goal 2.2:** Explain how trends in environmental variables are affected by the following management actions: | **Goal 2.3:** Understand how other environmental factors (e.g. contaminants, climate) affect trends in monitored environmental variables. | **Goal 2.4:** Evaluate a modify research a analytical priorities to support manageme needs. |
|---|---|---|---|---|---|---|
| **Survey Group 1: Multiple, Fixed Location Sampling** | | | | | | |
| Beach Seine | • Special status species (e.g. delta smelt, splittail, salmonids);<br>• Sport fish species (e.g. sturgeon, striped bass, American shad, catfish);<br>• Forage fish species (e.g. threadfin shad, inland silverside);<br>• Invasive species (e.g. mitten crabs); | • Assess and incorporate new variables | Yes | • Water project design and operations (e.g. exports, reservoir releases/flows, gate operations, fish facility design and operation);<br>• Use of environmental water (e.g. EWA, VAMP, CVPIA-b2);<br>• Ecosystem restoration (e.g. ERP, AFRP); | No | No |
| Bay Study | • Special status species<br>• Sport fish species<br>• Forage fish species<br>• Water quality (e.g. salinity, temperature, turbidity);<br>• Invasive species<br>• Other aquatic species of interest | • Assess and incorporate new variables | Yes | • Water project design and operations (e.g. exports, reservoir releases/flows, gate operations, fish facility design and operation);<br>• Use of environmental water (e.g. EWA, VAMP, CVPIA-b2);<br>• Ecosystem restoration (e.g. ERP, AFRP); | No | No |
| Fall Midwater Trawl* | • Special status species<br>• Sport fish species<br>• Forage fish species<br>• Invasive species | • Assess and incorporate new variables | Yes | • Water project design and operations (e.g. exports, reservoir releases/flows, gate operations, fish facility design and operation);<br>• Use of environmental water (e.g. EWA, VAMP, CVPIA-b2);<br>• Ecosystem restoration (e.g. ERP, AFRP); | No | No |

| Program | **Goal 1.1:** Determine the trends in environmental variables and trends in the distribution and abundance of living resources | **Goal 1.2:** Continually assess and improve the long-term monitoring program elements to support management priorities. | **Goal 2.1:** Determine interrelations hips among monitored variables. | **Goal 2.2:** Explain how trends in environmental variables are affected by the following management actions: | **Goal 2.3:** Understand how other environmental factors affect trends in monitored environmental variables. | **Goal 2.4:** Evaluate ar modify research ar analytical priorities to support manageme needs. |
|---|---|---|---|---|---|---|
| Summer Townet* | Special status species (e.g. delta smelt);<br>• Sport fish species<br>• Forage fish species<br>• Invasive species | • Assess and incorporate new variables;<br>• Field or analytical studies to assess current and new sampling methods;<br>• Review and improve monitoring program element processes;<br>• Using historical information to change the program element design; | Yes | • Water project design and operations (e.g. exports, reservoir releases/flows, gate operations, fish facility design and operation);<br>• Use of environmental water (e.g. EWA, VAMP, CVPIA-b2);<br>• Ecosystem restoration (e.g. ERP, AFRP); | No | No |
| 20 mm* | • Special status species<br>• Sport fish species<br>• Forage fish species<br>• Invasive species | No | Yes | • Water project design and operations (e.g. exports, reservoir releases/flows, gate operations, fish facility design and operation);<br>• Use of environmental water (e.g. EWA, VAMP, CVPIA-b2);<br>• Ecosystem restoration (e.g. ERP, AFRP); | No | No |
| Spring Kodiak Trawl* | • Special status species<br>• Sport fish species<br>• Forage fish species<br>• Invasive species | • Assess and incorporate new variables<br>• Evaluation of new technologies or new gear types;<br>• Review and improve monitoring program element processes;<br>• Using historical information to change the program element design; | No | • Water project design and operations (e.g. exports, reservoir releases/flows, gate operations, fish facility design and operation); | No | No |

| Program | Goal 1.1: Determine the trends in environmental variables and trends in the distribution and abundance of living resources | Goal 1.2: Continually assess and improve the long-term monitoring program elements to support management priorities. | Goal 2.1: Determine interrelations hips among monitored variables. | Goal 2.2: Explain how trends in environmental variables are affected by the following management actions: | Goal 2.3: Understand how other environmental factors affect trends in monitored environmental variables. | Goal 2.4: Evaluate ar modify research ar analytical priorities to support manageme needs. |
|---|---|---|---|---|---|---|
| Juvenile Sturgeon | • Sport fish species | • Evaluation of new technologies or new gear types;<br>• Review and improve monitoring program element processes;<br>• Using historical information to change the program element design; | No | No | No | No |
| Suisun Marsh | • Special status species<br>• Sport fish species<br>• Forage fish species<br>• Water quality<br>• Lower trophic level species (e.g. phytoplankton, zooplankton, mysids);<br>• Predators<br>• Invasive species<br>• Other aquatic species of interest | • Assess and incorporate new variables | Yes | • Water project design and operations (e.g. exports, reservoir releases/flows, gate operations, fish facility design and operation);<br>• Ecosystem restoration (e.g. ERP, AFRP); | No | No |
| North Bay Aqueduct | • Special status species<br>• Sport fish species<br>• Forage fish species<br>• Invasive species | • Using historical information to change the program element design; | Yes | • Water project design and operations (e.g. exports, reservoir releases/flows, gate operations, fish facility design and operation); | No | No |
| **Survey Group 2: Fixed Strata, Random Location** | | | | | | |
| Resident Fishes | • Forage fish species<br>• Predators<br>• Invasive species | • Review and improve monitoring program element processes;<br>• Using historical information to change the program element design; | No | • Water project design and operations (e.g. exports, reservoir releases/flows, gate operations, fish facility design and operation);<br>• Ecosystem restoration (e.g. ERP, AFRP); | No | No |

| Program | **Goal 1.1:** Determine the trends in environmental variables and trends in the distribution and abundance of living resources | **Goal 1.2:** Continually assess and improve the long-term monitoring program elements to support management priorities. | **Goal 2.1:** Determine interrelations hips among monitored variables. | **Goal 2.2:** Explain how trends in environmental variables are affected by the following management actions: | **Goal 2.3:** Understand how other environmental factors affect trends in monitored environmental variables. | **Goal 2.4:** Evaluate ar modify research ar analytical priorities to support manageme needs. |
|---|---|---|---|---|---|---|
| **Survey Group 3: Single, Fixed Location Sampling** | | | | | | |
| SWP and CVP Fish Salvage* | • Special status species<br>• Sport fish species<br>• Forage fish species<br>• Predators<br>• Invasive species | • Field or analytical studies to assess current and new sampling methods;<br>• Evaluation of new technologies or new gear types;<br>• Review and improve monitoring program element processes; | Yes | • Water project design and operations (e.g. exports, reservoir releases/flows, gate operations, fish facility design and operation);<br>• Use of environmental water (e.g. EWA, VAMP, CVPIA-b2);<br>• Ecosystem restoration (e.g. ERP, AFRP); | No | No |
| Chipps Island Trawl | • Special status species<br>• Sport fish species<br>• Forage fish species<br>• Invasive species | • Assess and incorporate new variables<br>• Field or analytical studies to assess current and new sampling methods;<br>• Review and improve monitoring program element processes;<br>• Using historical information to change the program element design; | Yes | • Water project design and operations (e.g. exports, reservoir releases/flows, gate operations, fish facility design and operation);<br>• Use of environmental water (e.g. EWA, VAMP, CVPIA-b2);<br>• Ecosystem restoration (e.g. ERP, AFRP); | No | No |

| **Program** | **Goal 1.1:** Determine the trends in environmental variables and trends in the distribution and abundance of living resources | **Goal 1.2:** Continually assess and improve the long-term monitoring program elements to support management priorities (e.g. new variables, methods) | **Goal 2.1:** Determine interrelation-ships among monitored variables | **Goal 2.2:** Explain how trends in environmental variables are affected by the following management actions: | **Goal 2.3:** Understand how other environmental factors affect trends in monitored environmental variables. | **Goal 2.4:** Evaluate a modify research a analytical priorities to support manageme needs. |
|---|---|---|---|---|---|---|
| Sacramento River and Mossdale Trawls | • Special status species<br>• Sport fish species<br>• Forage fish species<br>• Invasive species | • Assess and incorporate new variables<br>• Field or analytical studies to assess current and new sampling methods;<br>• Review and improve monitoring program element processes;<br>• Using historical information to change the program element design; | Yes | • Water project design and operations (e.g. exports, reservoir releases/flows, gate operations, fish facility design and operation);<br>• Use of environmental water (e.g. EWA, VAMP, CVPIA-b2);<br>• Ecosystem restoration (e.g. ERP, AFRP); | No | No |
| **Survey Group 4: Flexible Location Sampling** | | | | | | |
| Adult Sturgeon Tagging | • Sport fish species | • Analytical studies to evaluate current and new analytical methods;<br>• Review and improve monitoring program element processes;<br>• Using historical information to change the program element design; | Yes | No | No | No |
| Adult Striped Bass Tagging | • Sport fish species | • Field or analytical studies to assess current and new sampling methods;<br>• Analytical studies to evaluate current and new analytical methods;<br>• Evaluation of new technologies or new gear types;<br>• Review and improve monitoring program element processes;<br>• Using historical information to change the program element design; | No | No | No | No |

## 5.3. General Strengths and Weaknesses of Survey Designs

Surveys in Group 1 sample fishes from the same set of locations periodically year after year (Table 2.1). Absent a major physical change to the sampling location, the sampling gear is assumed to work approximately the same over time, reducing the effect of varying location characteristics on how well the gear captured fishes. Also, occupying the same locations improves the likelihood of successfully deploying and retrieving gear as boat operators become familiar with the conditions and obstructions and avoid or adapt to them. This type of sampling produces relative abundance estimates that are assumed to be strongly related to changes in absolute population size. However, since Group 1 survey sites were not originally picked at random, they may inadvertently bias results (i.e., they may represent particularly good or poor habitats). For this reason, generalizations from individual survey abundance to target population abundance should be made with caution. Surveys in this group can also identify shifts in species distribution between survey intervals and years; the broader the survey range the less likely a shift in distribution will be interpreted as a change in abundance.

The Resident Fishes Survey (Group 2, Table 2.1) is the only current survey selecting sample elements (500m segments of shoreline to electro-fish) at random for each sampling interval. Random selection of sampling elements allows inferences to be made concerning the populations of shoreline fishes targeted and collected well (see Appendix B-10, Delta Resident Shoreline Fishes Survey). Provided with caveats, which can be substantial, regarding the effectiveness of electrofishing on particular fish species of interest, this survey can produce abundance indices directly related to the population size for the geographic range sampled. Random selection of sample elements (shoreline reaches) does not allow location to location distribution comparisons. However, it strengthens spatial comparisons across regional strata, which have remained consistent since the re-initiation of the survey in 1995. Since electrofishing draws fishes out from among obstructions, this gear is well suited to random site selection because underwater obstructions and vegetation, common along shorelines, pose less of a problem for electrofishing than for trawls or seines.

Single location sampling surveys (Group 3, Table 2.1) provide valuable indices of abundance for migratory species funneling past the site, assuming that sampling encompasses most or all of the migratory period and sampling gear is appropriate for the species/life stage. Current year-round sampling ensures migratory periods are completely sampled. High sample volumes for several surveys enhance the likelihood of detecting a rare fish species. Such surveys also provide valuable abundance information for non-migratory fishes if auxiliary information indicates that the sampling location is centrally located within the species' range and that changes in catch are unrelated to shifts in distribution. Without such life history or supplementary distributional information, however, single-site abundance estimates should be suspect.

The geographically flexible, temporally narrow sampling surveys (Group 4, Table 2.1) use mark-recapture methodology to estimate population size. Mark-recapture studies,

under the best conditions, can provide population estimates and measures of precision of the estimate. Data can also be used to estimate total mortality, or fishing mortality if fishermen are interviewed or induced to return tags through rewards (interviews and reward tags are current practices). However, mark-recapture studies are data intensive for an unbiased estimate. Moreover, assumptions necessary for estimation are often difficult or impossible to test, or they may be known to be invalid. In such cases, the resulting real and potential biases should be acknowledged and discussed.

## 5.4. Survey Effectiveness by Lifestage for Species and Habitat

Long-term fisheries monitoring employs a great variety of gear, from nets designed to retain 5-6 mm larvae, to nets or traps that can retain 120 cm striped bass or 310 cm white sturgeon. Half the surveys use towed nets that were most effective for fish during their first year of life. Late-fall Chinook salmon were not included among species of interest in our questionnaire, but surveys effectively tracking fall Chinook salmon abundance and distribution will be equally effective for late-fall fish (Table 5.2).

Only North Bay Aqueduct continued to use gear targeting larvae as of 2003, although three other surveys used ichthyoplankton nets previously: the Bay Study 1980-1989 , the Striped Bass Project 1968-1995 and Suisun Marsh 1994- 2002. Other surveys employ gear that successfully retains early to late-stage larvae and salmonid fry well: Beach Seine (fry only), Summer Townet, 20-mm Survey, Suisun Marsh beach seine, Chipps Island (fry only), Sacramento Trawl (fry only), and Mossdale Trawl surveys (fry only). The FWS surveys (i.e., Beach Seine, Chipps Island, Sacramento and Mossdale trawls) only keep record of fish ≥ 25 mm, with few exceptions, so true larvae are no longer identified and enumerated, but salmonid fry continue to be. One or more surveys reported effectively monitoring all species of concern at the larva/fry stage except coastal steelhead, green sturgeon, and starry flounder (Table 5.2). For these three species, early life-stages are rarely present within the sampling range of any of the 16 surveys.

Sport fishes are also well sampled at this life stage, except for white sturgeon (whose larvae probably rear upstream) and catfish (whose larvae rear near structure in benthic habitats). However, larvae and fry are not well sampled across all habitats of interest. In particular, Nearshore Vegetated, Nearshore Other Structures, Marsh, Floodplain and Benthic habitats are not well sampled for larvae and fry (Table 5.2). The FWS Beach Seine captures many late stage larvae, but due to the copious numbers and identification challenges in the field, FWS imposed a minimum size of reporting (≥25 mm) in 1995. This minimum threshold did not affect collection or reporting of salmon fry data. The FWS Beach Seine remains the best gear and survey for assessing fry distribution and entry into the Delta for all Chinook salmon races.

Age-0 and smolt-sized fishes are well monitored by 12 of the 16 surveys (Table 5.2). All species of concern are well sampled at this stage, except for coastal steelhead and green sturgeon. Delta smelt are particularly well sampled. Except for white sturgeon and catfish, all sport fishes are similarly well sampled (Table 5.2). Shoreline fishes

larger than 20-30 mm become vulnerable to capture by the Resident Fishes Survey, so largemouth bass and sunfishes inhabiting Nearshore Vegetated and Nearshore Structured habitats are well sampled at this stage. Also, Bay Study and Suisun Marsh otter trawl sampling effectively captures this life stage, improving abundance and distribution information for Benthic habitats. Marsh and Floodplain habitats remain poorly sampled by IEP surveys. Suisun Marsh, however, only samples a small proportion of Marsh habitat in San Francisco Estuary.

Age-1 or yearling fishes, categorized as “A” in Table 5.2, are captured effectively by 10 of 16 surveys, but the species overlap among surveys diminishes for fishes at this age. For example, the Beach Seine and Townet surveys become ineffective for Chinook salmon and for striped bass of this age, respectively. Nonetheless, the same seven of nine species of concern are still well sampled by one or more surveys (Table 5.2). Sport fishes of interest are less well sampled, in part because fall-run Chinook, American shad, and surfperches of this age are rare in the estuary and most surveys do not sample frequently enough to catch them when available. Habitats sampled effectively remained the same as for age-0 fishes, except that the Beach Seine Survey lost effectiveness for age-1 fishes, and sampling redundancy in Nearshore habitats decreased.

As fishes reached and surpassed age-2 (also categorized as “A” in Table 5.2), most trawl surveys become ineffective at capturing them. However, surveys targeting older juvenile and adult sturgeon or striped bass are effective, particularly the Juvenile Sturgeon Tagging, Adult Sturgeon Tagging, and Adult Striped Bass Tagging (Table 5.2). Several trawl surveys reportedly collect smaller species (e.g., longfin smelt and starry flounder) that composed some of this category: Bay Study, Fall Midwater Trawl, Suisun Marsh, and Chipps Island and Sacramento trawls. In addition, Salvage remains effective for age-2 or adults of some species of concern. The Resident Fishes Survey continues to sample well those species inhabiting all Nearshore habitats (Table 5.2).

None of the 16 IEP long-term monitoring surveys sampled coastal steelhead (i.e., from tributaries west of Carquinez Strait within the estuary), green sturgeon or catfish well; and starry flounder, white sturgeon (adults only), largemouth bass and all other sunfishes, and surfperches were only monitored well by single surveys. The Suisun Marsh Survey included Tule perch among the surf perches, which is the basis for its high surf perch rating (Table 5.2).

This section reviewed only the best sampled species-life-stages and habitats, and shows that the IEP Fish Monitoring Surveys as a group are gathering high quality abundance and distribution data for almost all the species and habitats of concern. The surveys together provide a broader and more complete view of the estuarine fish community than that provided by any single survey. Additional valuable information on survey sampling effectiveness can be found in individual survey questionnaire responses (see Appendix B for complete life-stage sampling ratings).

**Table 5.2 Fish Monitoring Surveys Rated Excellent or Good for Abundance and Distribution by Groups/Species or Habitats. :** L = larvae and fry (larvae) J = age 0 and smolts (juveniles) A = age 1, age 2+ (adults)

| Group/Species | Multiple, Fixed Location Sampling | | | | | | | | | Fixed Strata, Random Location | Single, Fixed Location Sampling | | | | Flexible Location Sampling | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species of Concern | Beach Seine | Bay Study | FMT | Townet | 20mm | Spring Kodiak | Juvenile Sturgeon | Suisun Marsh | NBA | Resident Fish | Salvage | Chipps | Sac Trawl | Moss | Adult Sturgeon | Adult Bass |
| Winter-run Chinook | J | | | | | | | | | | J | J, A | J, A | | | |
| Spring-run Chinook | L, J | | | | | | | | | | J | J, A | J, A | | | |
| CV steelhead | L, J | | | | | | | | | | J, A | L, J, A | | | | |
| Coastal steelhead | | | | | | | | | | | | | | | | |
| Delta smelt | A | J, A | J, A | L, J | L, J | A | | A | L | | J, A | J, A | | | | |
| Splittail | J | | | | | | | J, A | | | J, A | J, A | | J | | |
| Longfin smelt | | J, A | J, A | L | L | | | J | L | | | J, A | | | | |
| Green sturgeon | | | | | | | | | | | | | | | | |
| Starry flounder | | J, A | | | | | | J | | | | | | | | |
| Sport Fishes | | | | | | | | | | | | | | | | |
| Fall-run Chinook | L, J | J | | | | | | | | | J | L, J, A | L, J | L, J | | |
| Striped bass | | J, A | J, A | L, J | L, J | | | J, A | L | | J | | | | | A |
| White sturgeon | | | | | | | A | | | | | | | | A | |
| Catfish | | | | L | | | | J, A | | A | J | | | | | |
| American shad | | J | J | L | L | J | | | L | | J | L, J | | | | |
| Largemouth bass | | | | | | | | | | J, A | | | | | | |
| Surfperch | | J | | | | | | A | | | | | | | A | |
| Habitats | | | | | | | | | | | | | | | | |
| Nearshore (NS) <2m | L, J | | | | | | | J, A | | J, A | | | | | | |
| NS vegetated | L, J | | | | | | | | | J, A | | | | | | |
| NS, other structures | | | | | | | | | | J, A | | | | | | |
| NS open water | | | J, A | | | J | | | | J, A | | | | L, J, A | | |
| Pelagic | | J, A | J, A | L | L | J, A | | | L | | J | L, J, A | L, J, A | L, J | | |
| Marsh | | | | | | | | J, A | | | | | | | | |
| Floodplain | L, J, A | | | | | | | | | | | | | | | |
| Mud, benthic | | J, A | | | | | | J, A | | | | | | | | |
| Detection/tracking of new invasions | Variable detection; good tracking | | | | L | | | J, A | L | | Poor to excellent detection; poor tracking | | | | | |

## 5.5. Missing Data and Effects

Missed sampling was inconsistently reported across surveys and difficult to interpret for some surveys, particularly for some surveys that varied locations sampled, months sampled, or sampling frequency within a month over time (e.g. FWS Beach Seine). For this section, we only identify instances when entire monthly or annual sampling intervals were missed. Appendix B contains additional information on missing data and effects for each of the surveys.

Sampling did not occur during entire months or years for nine of 16 surveys (Table 5.3). Missed survey months or years most often resulted from the need for cost savings (e.g. Bay Study, Adult Striped Bass) or boat breakdowns (e.g., Fall Midwater Trawl, Suisun Marsh).

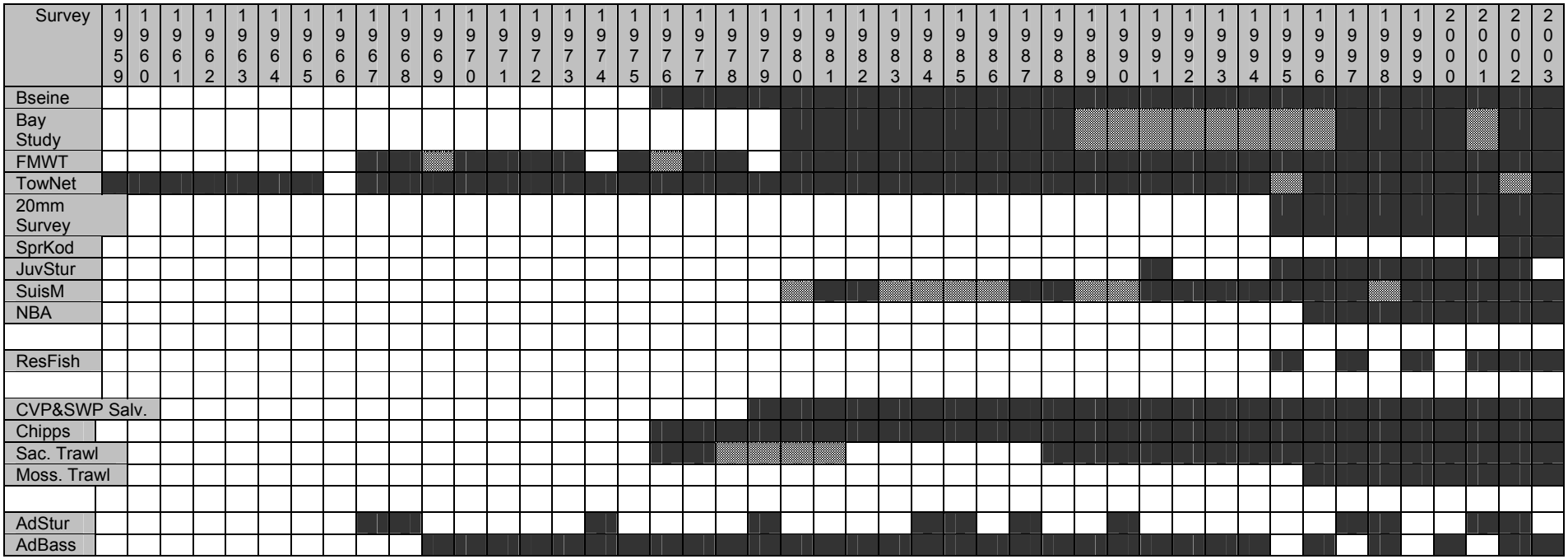
Significant effects resulted from missing survey data, including:

(1) An inability to calculate annual abundance indices for missed years and reduced sample sizes for water-year-type effects analyses, etc. (c.f. blanks, Table 5.3);

(2) The challenge of calculating indices with missing survey months (e.g., Suisun Marsh) or calculating abundance indices from data limited to sub-optimal months (e.g., Bay Study) or from index fabrication based upon patterns from similar years (e.g., Fall Midwater Trawl) (c.f. gray fill, Table 5.3);

(3) A reduction in precision of population estimates because recapture samples occur two years post-marking rather than one (e.g., Adult Striped Bass, Table 5.3) or at even more infrequent intervals (e.g., Adult Sturgeon, Table 5.3).

**Table 5.3 Long-term Fisheries Monitoring Survey Durations**, including years in which one or more months were missed (checked) or no sampling occurred (blank). Variations in sampling station number or location are not recognized in this table.



## 5.6. Proportions of Field Effort by CBDA Region

Long-term fisheries monitoring survey sampling occurred in all CBDA monitoring regions, though only one survey sampled in Upstream Sacramento and Upstream San Joaquin River Regions and two sampled in Central and South San Francisco Bay Region (Table 5.4). Sampling effort was high in all Delta regions, Suisun Bay/Marsh, and San Pablo Bay. This reflects the sampling design responses to the need for information on fish species and fish communities in the vicinity of and downstream of the south delta water export facilities, and a focus on species of concern, such as juvenile Chinook salmon, striped bass, and delta smelt, all of which migrate through or rear within the regions.

**(duplicate of) Figure 1.1. San Francisco Estuary Monitoring Regions**

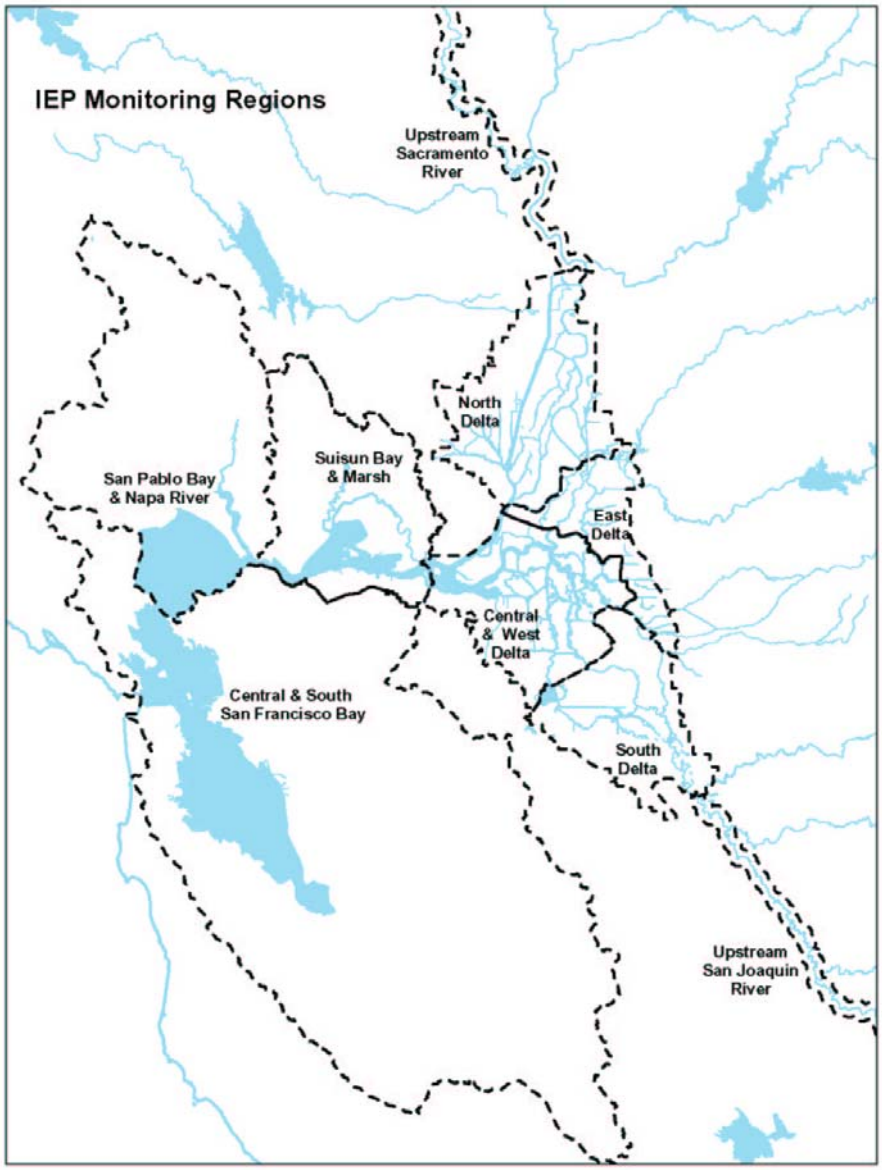


**Table 5.4 Station Number and Proportions of IEP Long-term Fish Monitoring Survey Stations within each CBDA Monitoring Region** (see Figure 1.1).

| | **Survey** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Group/Species** | Multiple, Fixed Location Sampling | | | | | | | | | Fixed Strata, Random Location | Single, Fixed Location Sampling | | | | Flexible Location Sampling | |
| | Beach Seine | Bay Study | Fall Midwater Trawl | Townet | 20mm | Spring Kodiak | Juvenile Sturgeon | Suisun Marsh | NBA | Resident Fish | Salvage | Chipps | Sac Trawl | Moss Trawl | Adult Sturgeon | Adult Bass |
| **Total Station Number** | 57 | 52 | 116 | 32 | 41+5[a] | 39 | 21 | 21 | 8 | 20 | 2 | 1 | 1 | 1 | n/a | n/a |
| **CBDA/IEP Monitoring Regions** | | | | | | | | | | | | | | | | |
| Upstream Sacramento River | 11 (19%) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| North Delta | 6 (11%) | 2 (4%) | 10 (9%) | 1 (3%) | 2 (5%) | 6 (15%) | 0 | 0 | 8 (100%) | 3 (15%) | 0 | 0 | 1 (100%) | 0 | 0 | 0 |
| East Delta | 4 (7%) | 0 | 5 (4%) | 2 (6%) | 1 (2%) | 5 (13%) | 0 | 0 | 0 | 5 (25%) | 0 | 0 | 0 | 0 | 0 | 0 |
| Central & West Delta | 14 (25%) | 10 (19%) | 33 (28%) | 14 (44%) | 17 (39%) | 13 (33%) | 6 (30%) | 0 | 0 | 8 (40%) | 0 | 0 | 0 | 0 | 0 | 1 (100%) |
| South Delta | 9 (16%) | 0 | 2 (2%) | 0 | 2 (5%) | 1 (3%) | 0 | 0 | 0 | 4 (20%) | 2 (100%) | 0 | 0 | 1 (100%) | 0 | 0 |
| Upstream San Joaquin River | 3 (5%) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Suisun Bay & Marsh | 0 | 10 (19%) | 41 (35%) | 13 (41%) | 13 (32%) | 13 (33%) | 12 (55%) | 21 (100%) | 0 | 0 | 0 | 1 (100%) | 0 | 0 | 0 | 0 |
| San Pablo Bay & Napa River | 4 (7%) | 10 (19%) | 25 (22%) | 2 (6%) | 7+5[a] (17%) | 1 (3%) | 3 (15%) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (100%) | 0 |
| Central & South San Francisco Bay | 6 (11%) | 20 (38%) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[a] Stations sampled during years with high flows only.

## 5.7. Shifts in Sampling Area

Shifts in sampling area have occurred in 6 of 9 surveys in Group 1 (geographically systematic sampling surveys, Table 5.5). No shift occurred for the Resident Fishes Survey (Group 2) and only a single survey reported a shift among those in Group 3, the Sacramento Trawl (Table 5.5). Sampling locations for group 4 were never static, so this question is not applicable.

Changes in station density and range most often occurred within a couple years of survey initiation or when a management question or a new species of concern exposed a sampling limitation that additional sampling could remedy.

Reasons for such shifts include:

(1) Adding stations to more effectively sample target species or habitats based upon current information and management need (e.g., Beach Seine 1977-81; Bay Study 1988, 1991, 1994; Fall Midwater Trawl 1968-78; Suisun Marsh 1994; Table 5.5);

(2) Adding or dropping stations coincident with outflow induced distributional shifts of target species (e.g., historically, Fall Midwater Trawl; recently, Townet, 20 mm);

(3) Adding stations to improve sampling for new special status species (e.g., Beach Seine 1992-1994 for winter-run Chinook; Fall Midwater Trawl 1990-1992 for delta smelt);

(4) Removing stations to save money and reduce redundancy across surveys (e.g., Beach Seine in 1983, which was redundant with Bay Study at the time; Fall Midwater Trawl in 1980, because stations were redundant with Bay Study and not important for striped bass; and Townet 1996-1998, due to money savings and stations often not important for striped bass; Table 5.5).

Although the Chipps Island survey considered moving downstream to reduce incidental take of delta smelt, no funds have been available to investigate the effects and feasibility of such a move. Also, net modification (1/4” to 5/16” codend mesh, June 2001) has reduced take of small delta smelt.

**Table 5.5 Changes in Sampling Station Density, Range (additions and removals) and Location, and the Years of Occurrence (in parentheses) for IEP Long-term Fish Monitoring Surveys.[3] Not applicable for Survey Group 4.**

| Survey (start yr) | Current Station Number | Stations Added within Range | Stations Added Extending Range | Stations Removed within Range | Stations Removed Reducing Range | Stations Shifted |
|---|---|---|---|---|---|---|
| **Survey Group 1: Multiple, Fixed Location Sampling** | | | | | | |
| Beach Seine (1977) | 57 | • 6 (1977-81) East & Central Delta,<br>• 8 ( 1992-94) Central Delta & Sac R<br>• 1 (1997) So Delta | • 11 (1977-81) SJ Delta, SPB, SFB<br>• 9 (1992-4) So Delta, SJR,<br>• 9 (1996-7) SPB, SFB<br>• 1 (2002) SJR | • 1 (1979) North Delta | • 5 (1983) SF Bay, SPB | |
| Bay Study (1980) | 52 | • 6(1988) South – Suisun Bay | • 1 (1988), 4 (1991), 6 (1994) all in SJ Delta | | | |
| Fall Midwater Trawl (1967) | 116 | • 21 (1968-1978) Suisun Bay and Delta | • 24 (1968) SF Bay<br>• 16-18 (1990-92) No Delta, Mok R | | • 27 (1980) SF Bay | |
| Townet (1959) | 32 | • 4 (1961-62) | • 3 (1961) East & So Delta<br>• 1 (1967) SPB, 2 (1974) SPB, 1 (1983) SPB, 2 (1995) SPB | | • 5 (1996-1998) SPB | |
| 20 mm (1995) | 41 | • 5 added in high flow years in San Pablo Bay | | • 3 (1995) West Delta, SPB, Napa R | | |
| Spring Kodiak (2002) | 39 | | | | | |
| Juvenile Sturgeon (1991) | 21 | | | | | |
| Suisun Marsh (1980) | 21 | | • 2 (1994) Eastern Marsh | • 6 ca (1981) | | |
| North Bay Aqueduct (1995) | 8 | | | | | |

[3] Blanks indicate no added, moved or removed stations.

| Survey (start yr) | Current Station Number | Stations Added within Range | Stations Added Extending Range | Stations Removed within Range | Stations Removed Reducing Range | Stations Shifted |
|---|---|---|---|---|---|---|
| **Survey Group 2: Fixed Strata, Random Location** | | | | | | |
| Resident Fish (1995) | 20 | | | | | |
| **Survey Group 3: Single, Fixed Location Sampling** | | | | | | |
| Salvage (1979) | 2 | | | | | |
| Chipps Island Trawl (1976) | 1 | | | | | |
| Sacramento Trawl (1976) | 1 | | | | | • To rm 55 from rm 43 (1988), to rm 35 &36 (1990) and return to rm 55 (1991) |
| Mossdale Trawl (1996) | 1 | | | | | |

## 5.8. Current Integration and Future Opportunities

The Fish and Wildlife Service and Fish and Game each report considerable personnel and equipment (e.g., research vessel) integration among their own surveys and with surveys of the other agency. UC Davis also reports personnel and equipment integration across several Suisun Marsh surveys other than fisheries. FWS and DFG boat operators are almost completely interchangeable among their own agency's surveys; DFG operators can run all Fish and Wildlife trawl surveys and one Fish and Wildlife operator can run Townet and 20mm (knowledge of DFG survey station locations and gear deployment techniques requires substantial time and training). Similarly, biological lead persons for FWS and DFG are interchangeable for two or more surveys. FWS and DFG share lab space and some key entry duties.

FWS Beach Seine, Sacramento Trawl, Chipps Island Trawl, and Mossdale Trawl integrate data on salmonid catch, length, and distribution from locations throughout the rivers and Delta, including data from CVP and SWP Salvage facilities. FWS survey data and CVP and SWP salvage data on Chinook salmon races of concern, some of it conveyed on an almost real-time basis via the internet, has been used by water and resource managers when making decisions on export levels. They also request, collect, and process fin-clipped salmon for coded wire tag recoveries; Bay Study, Fall Midwater Trawl, Spring Kodiak and Salvage annually return some coded-wire tagged Chinook salmon for tag recovery. FWS surveys also provide biological samples (otoliths, tissue samples for DNA) to DFG, DWR, NOAA Fisheries, and academic researchers.

Similar to FWS, DFG integrates data from several of its surveys, as well as with information from the Salvage facilities, to reduce delta smelt entrainment. Three surveys track distribution of larval and juvenile delta smelt, providing near real-time information for water export management decisions and fisheries regulators (North Bay Aqueduct, 20mm, Townet). Two surveys calculate abundance to determine delta smelt year-class strength (Townet and Fall Midwater Trawl) and a third is occasionally used for distribution information (Bay Study). The relatively new Spring Kodiak Trawl tracks distribution of maturing and mature delta smelt, providing near-real-time catch information used by water managers to reduce adult entrainment and to infer whether the next generation might hatch near the export pumps.

Information from juvenile delta smelt salvage has also proven very useful for predicting near-future salvage levels and to instigate changes in water export rates. Catch data from the Chipps Island Trawl survey has been used to track delta smelt abundance. The importance of survey data in delta smelt management has been emphasized by inclusion of the Fall Midwater Trawl, Townet, 20mm and Spring Kodiak Trawl surveys in the current OCAP. All the aforementioned surveys except North Bay Aqueduct have also contributed data and delta smelt specimens to UC Davis researchers investigating early life history, reproductive development, and behavior in front of diversion screens. In the future, near real-time spawner distribution information from the Kodiak Trawl surveys could allow researchers to locate and possibly characterize delta smelt spawning habitat in the wild.

The rapid dissemination of information through the Real-Time Monitoring process via the internet has facilitated water management decision making. Fish Salvage (DWR, USBR, DFG), FWS Beach Seine, Sacramento, Mossdale and Chipps Island Trawl surveys, and Delta Smelt 20 mm and Kodiak Trawl surveys all contribute information either daily or weekly to this process.

Three of four surveys originally designed to provide sequential striped bass life history information still remain, as the Striped Bass Egg and Larva survey was discontinued in 1995. The Townet Survey provides an index of initial recruitment in summer, which was compared against the fall index from the Fall Midwater Trawl to assess how well the cohort survived the summer. Agency and academic researchers have analyzed this survival index analyzed in relation to environmental and man-made conditions to assess relative affects of each. Striped bass numbers were next assessed by the Adult Striped Bass Survey as they entered the sport fishery (≥18”). Using mark-recapture methodology stratified by age and sex allowed the Adult Striped Bass Survey to estimate of adult population size, and through use of age-fecundity data, estimate annual egg production. Egg production estimates have been integrated with environmental (e.g., flow) and anthropogenic (e.g., entrainment loss) factors to model patterns of juvenile recruitment. Here again Salvage data provide important information.

The Bay Study has provided data and specimen collection for a variety of agency and academic researchers. It has contributed striped bass data to DFG Striped Bass and academic researchers, delta smelt data to the Delta Smelt Project, splittail data to the Splittail Investigations project, juvenile sturgeon data to the Young Sturgeon Project, returned fin-clipped Chinook salmon to the FWS, and provided ongoing collections for various species (e.g., lampreys, cusk-eels, cottids) to Robert Lea who has been investigating taxonomic questions for DFG. In return, Robert Lea provided confirming species identification checks. In addition, fish samples have been collected for Bob Spies (Lawrence Livermore Labs) and Don Watson (University of California Berkeley) among other researchers and graduate students. Bay Study has also coordinated with the Lower Estuary Zooplankton Sampling Project and provided crew and the RV Longfin as a sampling vessel for the Zooplankton project. The Bay Study noted the FWS Beach Seine survey now samples into San Pablo and Central bays at locations historically sampled by both surveys, and plans to use this inshore lower estuary sampling to further investigate the life history and abundance trends of jacksmelt and surfperches. Bay Study respondents noted that much potential exists for integration using other project data sets to answer questions about lower estuary species.

Several studies contribute information to assist the White Sturgeon Population Dynamics Program and program staff worked with other researchers to investigate whether green sturgeon in the estuary warranted listing as a threatened or endangered species. Bay Study and the Juvenile Sturgeon surveys provided information on year-class strength of juveniles which was incorporated with adult population and mortality estimates to evaluate the efficacy of fishing regulations for protecting white sturgeon. Project staff, in coordination with other agency and academic researchers, reviewed

green sturgeon catch data and provided recommendations to the listing agency. The Adult Sturgeon Tagging project has worked with DFG, other agency and academic researchers to capture white sturgeon for telemetry studies. Tagged fish have been tracked by both project personnel for identification of potential spawning grounds and other DFG personnel looking at fish migratory behavior near diversion points (e.g., Delta Cross Channel Studies).

IEP surveys already display a high level of integration with one another and with academic researchers. Generally, all surveys were willing to expand such integration. One way this might occur is through calculation of estuary-wide forage fish biomass indices. Several DFG surveys – Townet, Fall Midwater Trawl and Bay Study – have developed length-weight relationships for common estuarine fishes and shrimps and plan to estimate regional and temporal biomass trends for benthic and pelagic forage species.

## 6. Interpretation of Strengths and Weaknesses for Individual Surveys

This section presents, for each of the 16 surveys, individual strengths and weaknesses related to their abilities to address a principle goal of determining trends in abundance and distribution for target fish species (c.f., Table 5.1, Goal 1.1). Information developed for this section came from questionnaire responses, data reports and Review Team member knowledge and interpretation, and has been reviewed by questionnaire respondents for accuracy.

A potentially large, survey-independent weakness exits for monitoring the trends in abundance and distribution of naturally spawned (wild) Chinook salmon in the lower river system. Recent (2002-2003) FWS rough estimates of the number of hatchery produced juvenile Chinook salmon caught in the Chipps Island Trawl suggest they far out number the naturally spawned fish. Since the two groups are impossible to distinguish visually as large juveniles in the absence of a hatchery fin clip, the true number of wild juveniles caught, as well as the timing and lower river distribution, remains unknown, making protection and management problematic. A constant fractional mark applied to hatchery fish could be used to distinguish them from wild fish for proper management.

### 6.1. Summary by Survey

**Beach Seine Survey**

STRENGTHS

- Long-term, some sampling since 1976.
- Very broad geographic distribution of sampling locations, including Sacramento and San Joaquin river sites and San Pablo and San Francisco Bay sites not sampled by any other survey.

- Relatively effective for Chinook salmon fry and small nearshore fishes, particularly Cyprinidae.
- One of two surveys effective in capturing small nearshore fishes.
- Sampling currently year-round.
- Rapid data turnaround, particularly in spring.

WEAKNESSES

- Year-round sampling, but only consistent since circa 1992.
- Many sites are boat ramps, which may not be representative of available habitat and may bias catch results.
- Changes in months sampled over time substantially diminish possible inter-annual comparisons of catch trends.
- Historical data for fishes < 25 mm suspect due to species identification problems.

**Bay Study**

STRENGTHS

- Long-term, sampling since 1980.
- Very broad geographic distribution from western Delta through South San Francisco Bay.
- Year-round monthly sampling with two sampling gears.
- Only survey sampling open water in Central and South San Francisco bays.
- Only survey sampling demersal fishes effectively outside of Suisun Marsh.

WEAKNESSES

- Missing winter sampling from the late-1980s through mid-1990s constrains some abundance calculations from using all the months of most effective capture.
- Abundance and distribution data compiled and reported 3 months into the next year.

**Fall Midwater Trawl**

STRENGTHS

- Very Long-term, sampling since 1967.
- Broad geographic distribution of sample locations, from San Pablo Bay through the Delta and into the lower Sacramento and San Joaquin rivers.
- Relatively dense distribution of sample locations.
- Relatively effective for juvenile pelagic fishes, such as striped bass, delta smelt and longfin smelt.
- Relatively rapid data turnaround, indices within a week of survey end.

WEAKNESSES

- No sampling and no indices for two years, and one year missing two months and another missing one month where indices were estimated from previous data patterns.
- Almost all sampling within the Delta conducted in channels, whereas sampling in Suisun and San Pablo bays also includes sampling shoal areas (2-6 m deep).
- Sampling (September-December) often encompasses an environmental transition from low to high outflow and high to low water temperatures in Nov/Dec. Timing of the transition influences fish vulnerability and the abundance pattern observed.

**Townet**

STRENGTHS

- Very Long-term, sampling since 1959.
- Limited missing data.
- Broad geographic distribution, San Pablo Bay through the Delta, including Suisun Marsh.
- Currently, twice monthly sampling through 6 surveys, June through August (addresses weaknesses, bullet 1).
- Effective for pelagic fishes, such as young striped bass and open water species about 30 mm long available during sampling period.
- Relatively rapid data turnaround, indices calculated within a week of survey.

WEAKNESSES

- Historically, irregular starting date and variable number of surveys conducted annually limits utility of data to investigate trends for species whose spawning period, spawning locations, and early behavior are different from those of striped bass.
- Three years, one not sampled, where no striped bass index could be calculated.
- Only conducted during one to three months in summer.

**20mm**

STRENGTHS

- Broad geographic distribution.
- Consistent twice monthly sampling frequency provides extensive information for fish about 20 mm long.
- Effectively targets late-stage larval and juvenile delta smelt, and other open water pelagic species, such as striped bass.
- Rapid data turnaround, 24 hr to 2 days via web page.

WEAKNESSES

- Relatively short-term survey, only since 1995. Survey is just beginning to develop abundance trend information.
- Relies on intensive lab work involving a relatively large number of personnel to ensure a short turn around time on information (see Fig. 4.2).

**Spring Kodiak**

STRENGTHS

- Relatively effective for detecting distribution of maturing and ripe delta smelt.
- Rapid data turnaround, same day via phone.
- Several non-target species, particularly Chinook salmon juveniles, are relatively effectively captured.

WEAKNESSES

- Relatively short-term sampling history, only since 2002 (the much less effective Spring Midwater Trawl dates back to 1990 and 1967-1972 with some survey months not sampled during both periods).

**Juvenile Sturgeon**

STRENGTHS

- Only survey targeting juvenile white sturgeon to assess year-class strength before they enter the fishery.
- Gear and bait identified that are highly selective for sturgeon.

WEAKNESSES

- Limited duration -- functional since 1991 w/ data gaps -- so don't yet know whether year-class strength estimates are valid based on regression analysis with subsequent adult estimates.
- Irregular sampling history at the location of sampling and annual effort levels.
- Historically, bait availability was an issue.

**Suisun Marsh**

STRENGTHS

- Long-term, sampling since 1980.
- Only long-term sampling program assessing fish abundance in and use of marsh habitat.

- Effective at capturing demersal fishes and multiple age-classes of fishes in small channels.
- Effectively tracked trends in abundance within the Marsh (such trends were often different from those of the estuary as a whole).
- Somewhat complementary to Bay Study Otter Trawl sampling.

WEAKNESSES

- Under sampled pelagic fishes in deep channels and sloughs relative to small sloughs.
- Some variability in sampling sites during early years of survey.

**North Bay Aqueduct**

STRENGTHS

- Rapid data turnaround, about one day via web page.
- Only survey that targeted larval delta smelt.

WEAKNESSES

- Limited geographic range.
- Sampling gear not very effective at capturing larval delta smelt.
- Sampling locations result in data of limited value in describing distribution of larval delta smelt.
- Intensive lab work and high chemical use and handling required.

**Resident Fishes**

STRENGTHS

- Samples throughout Delta.
- One of only three surveys effectively sampling shallow water (<2m).
- Only survey that effectively samples fishes associated with dense vegetation or other structure.
- Samples fishes older than age-0 well.

WEAKNESSES

- Relatively short-term survey, reinitiated in 1995.
- Gear efficiency adversely affected by salinity and turbidity.

**State Water Project and Central Valley Project Fish Salvage**

STRENGTHS

- Long-term sampling, since 1975 for striped bass and Chinook salmon.
- Extremely large volumes of water sampled and species counts can be high even for uncommon species.
- Rapid data turnaround, about one day via web page.
- Sampling year-round.
- Captures multiple age groups well, including age-0.

WEAKNESSES

- For single location sampling, salvage facilities do not intercept fishes from an exclusive migratory corridor, so changes in abundance of migratory species cannot be distinguished from changes in migratory path without supplementary distribution information.
- For single location sampling, changes in abundance of non-migratory species cannot be distinguished from changes in distribution without supplementary distributional information.
- Sampling dependent upon water export pumping.
- Fish identification was a problem for some species up to the early 1980s, and for delta smelt until 1993.
- Data available for period prior to 1979, but has not been entered into a database and is not available via the web.
- Proportion of samples in which fish were identified in addition to enumerated has varied over time. At the CVP facility, fish were identified to species during every sample beginning in November, 1992 and beginning in July, 1992 at the SWP facility. Prior to this time, fish were identified at 0100 and 1300 and sporadically during other samples. Historically, daily salvage estimates were extrapolated based on these 2 samples.

**Chipps Island Trawl.**

STRENGTHS

- Long-term sampling, since 1976.
- Perhaps the most effective IEP survey at capturing emigrating juvenile salmonids and documenting annual recruitment trends from the Central Valley, including winter- and spring-run Chinook salmon and steelhead.
- Relatively useful, in conjunction with non-IEP coded wire tag studies, assessing salmonid survival through differing migratory paths within the delta, and in indexing or estimating numbers passing.
- Rapid data turnaround, about one day via web page.
- Emigrating fish must pass sampling site.
- Captures pelagic, non-target species, such as splittail, delta smelt and American shad.
- Complements seine data.

WEAKNESSES

- For single location sampling, changes in abundance of non-migratory species cannot be distinguished from changes in distribution without supplementary distribution information.
- Although currently samples year-round (since 1994), long-term data only available for spring.
- Potential for high take of delta smelt may at times necessitate reducing sampling.
- A June 18, 2001 change in cod-end mesh from ¼ to 5/16" may have subsequently affected catches of small fishes and thus their trends.

**Sacramento River Trawl**

STRENGTHS

- Long-term sampling, since 1976.
- Captures emigrating juvenile salmonids including winter- and spring-run Chinook salmon.
- Detects salmonid entry into the Delta.
- Rapid data turnaround, about one day via web page.
- Complements beach seine sampling.
- All emigrating and anadromous fish in Sacramento River must pass site unless weirs are spilling into the Yolo Bypass.

WEAKNESSES

- For single location sampling, changes in abundance of migratory species confounded when weirs spill into the Yolo Bypass, providing an alternate migration route.
- For single location sampling, changes in abundance of non-migratory species cannot be distinguished from changes in distribution without supplementary distribution information.
- Low fish catches in summer and fall when few fishes emigrate and water is clear.
- Sampling gaps in the late 1970s through late 1980s.
- Catch efficiency is thought to be a function of water clarity, which is highly variable in the Sacramento River and changes substantially at this location seasonally, confounding quantification of emigration patterns and relative population levels, etc.
- Long-term sampling data only available for spring months, not year-round.
- Sampling is not comparable year-round due to a gear change: Midwater trawl is used for part of the year (Apr-Sept) and Kodiak trawl is used for remaining months (Oct-Mar).
- Kodiak trawl is personnel and boat intensive.

**Mossdale Trawl**

STRENGTHS

- Reasonably effective at capture of emigrating juvenile salmonids and documenting annual recruitment trends from San Joaquin River tributaries.
- Detects salmonid entry into the Delta and proximity to the Water Export Facilities.
- Rapid data turnaround, about one day via web page.
- All emigrating fish must pass site.
- Complements beach seine data.
- Moderately effective at capture of emigrating juvenile splittail and American shad when present.

WEAKNESSES

- For single location sampling, changes in abundance of non-migratory species can not be distinguished from changes in distribution without supplementary distribution information.
- Few migratory species in San Joaquin River besides fall-run Chinook salmon and some steelhead.
- Summer, fall (only since 1995), and early winter sampling catches very few fish and Kodiak trawl is personnel and boat intensive relative to numbers caught.

**Adult Sturgeon Survey**

STRENGTHS

- Only survey collecting information on population trends of adult white and green sturgeon.
- Only survey collecting information on adult white sturgeon mortality rates.
- Data collected in a manner allowing estimation of absolute population size and precision of the estimate.

WEAKNESSES

- Accurate and relatively precise population estimates are data intensive – needing high numbers of tagged individuals in the population and good numbers of recaptures.
- Mark-recapture estimate assumptions are difficult to impossible to test, and some assumptions are violated..
- Specificity of sampling severely limits utility of data for non-target species.

**Adult Striped Bass Survey**

STRENGTHS

- Only survey collecting information on adult striped bass population trends.
- Data collected in a manner allowing estimation of absolute population size and precision of estimate.

WEAKNESSES

- Recent every other year sampling reduced precision of the estimate.
- Accurate and relatively precise population estimates are data intensive and need high numbers of tagged individuals in the population and good numbers of recaptures.
- Mark-recapture estimate assumptions are difficult to impossible to test and some are violated.
- Specificity of sampling severely limits utility of data for non-target species.

## 7. Continually Assess and Improve Program Elements to Support Management Priorities

All projects have proposed, recently conducted assessments, or made improvements to their survey, although questionnaire respondents may not have acknowledged all efforts (e.g., the development of more elaborate web page data display for the 20 mm Survey). Responses focused primarily on reviewing and improving monitoring element processes, which would improve accuracy of data and speed of data availability, but not adversely affect data comparability. This was not unexpected since the main objective of long-term monitoring has been to gather comparable data through time, which, in turn, has been accomplished by using the same net design and fishing methods. The need for consistent gear and methods limits 'improvements' that can be made without affecting result comparability. For this reason there are few examples of fishing gear or methods modifications.

One example of a gear revision, the Spring Kodiak Trawl survey, resulted from a 2001 review of information from a 1994 special study and compatibility of a gear change—midwater trawl to a Kodiak trawl—with the main goal of detecting the distribution of ripe adult delta smelt (spawners). In the 1994 study, samples of delta smelt catch per cubic meter of water filtered were compared for repeated side by side tows of a traditional Midwater Trawl, a Chipps Island trawl and a Kodiak Trawl. The Kodiak Trawl catch per cubic meter averaged more than two orders of magnitude higher than that of the Midwater Trawl. Since the Midwater Trawl project goal was to determine distribution and in particular the numbers and proportion of adult delta smelt near the water export pumps, improved detection by the Kodiak Trawl better addressed the goal. However, the feasibility of a geographically broad Kodiak Trawl survey was not investigated and approved until fall 2001. Initiated in winter 2002, the survey detects adult delta smelt use of the Delta and provides timely information (same day via phone) to inform water management decisions. Survey personnel continue to work on field and lab processes to shorten reporting time and automate its web presentation.

Appendix B contains questionnaire responses about assessments and improvements made to each survey. In part because of staff and equipment integration, responses were often similar or the same for projects within the same program (e.g., Beach Seine, Chipps Island, Sacramento Trawl, and Mossdale Trawl in the FWS Salmon Program or Bay Study, Fall Midwater Trawl and Townet in the DFG Long-term Monitoring Program).

Five surveys report assessing or planning to incorporate new variables. The Suisun Marsh survey recently incorporated measurement of dissolved oxygen to its data collection. The Spring Kodiak Trawl survey has worked on improving their recognition and ranking of delta smelt maturity status. Bay Study, Fall Midwater Trawl, and Townet surveys have worked together to gather length-weight information for common estuarine fish species with the goal of developing a forage biomass index.

Eight surveys report proposing or conducting field or analytical studies to assess current or new sampling methods, including the Kodiak Trawl Survey's midwater-Kodiak trawl comparison already discussed. The Fall Midwater Trawl survey has proposed to use a Didson camera (sonar) to image the mouth size, shape and movement of its net during deployment. This is to be part of a larger gear deployment comparison between Research Vessel Longfin and the Research Vessel New Alosa, reported by the Bay Study and Townet, that will also use time-depth recorders (new technology) to confirm whether current methods of judging net depth (i.e., cable out and cable angle) are accurate or should be revised. Townet staff has been analyzing trends in young striped bass diet data and will assess its usefulness in exploring life history questions and possibly explaining abundance patterns. The Suisun Marsh project proposed to study effects of bottom trawling on benthic fauna, but this proposal was not funded. They have also tried collecting fish with various other gears (e.g., block nets) and have added beach seine sampling to their monthly surveys. The Salvage surveys are assessing current sampling methods and developing new ones, such as covering louvers during the day to improve salvage. Finally, the Chipps Island survey reported that minor modifications to sampling methods are evaluated frequently. For example, a mid-1990s study on increasing mesh size to reduce delta smelt by-catch without changing salmonid capture efficiency resulted in changing the codend mesh size of the net used at that location.

Only four studies reported conducting or proposing any analytical studies to evaluate current or new analytical methods. The Bay Study reported on the collaborative work of a UC Davis post-doc and staff to develop alternative index calculations (e.g., presence-absence) and use of non-parametric Friedman's ANOVA to test for differences in measures of abundance and distribution. This non-parametric ANOVA will be a useful tool for all surveys. The Suisun Marsh Survey's publication record attests to their continued efforts to incorporate new analytical methods, and they have also worked with the Bay Study post-doc. Finally, both Adult Sturgeon and Adult Striped Bass projects propose to work with a statistician to validate current methods of calculating confidence intervals for population estimates.

Respondents reported only three examples of new technology or gear use, including changes to the Juvenile Sturgeon bait selectivity (which stretches the intended definition of new technology or gear). To ensure the gear is fishing as intended, use of time-depth recorders could become a regular part of quality control for three surveys. The most recent example of a technology updated involves the Townet Survey use of web technology for a near real-time display of species, density, and length-frequency distribution (similar to the web technology of the 20 mm survey).

Eleven of 16 surveys reported some effort to review and improve monitoring element processes, and half (8 surveys) listed quality control and quality assurance examples. The FWS hired a biologist experienced in taxonomy to improve and review fish identification for their four surveys. FWS reports that implementation of a minimum length for reporting has improved correct identification and sped up processing. The Bay Study has implemented a quality check and reporting program to assess whether fish, shrimps, and crabs were effectively separated from debris, identified and measured correctly in the field. Townet again reported that their review of young striped bass diet data may result in new procedures if the analyses indicate value to reinstating this task.

As a new project, the Spring Kodiak Trawl is still revising field and lab processes to make net deployment safer and easier, consistently rank delta smelt gonad maturity, and expedite data processing for the web. The goal is to reduce information dissemination time. The Salvage survey has also instituted new studies to improve efficiency of data transfer and dissemination. Finally, Resident Fish, Adult Sturgeon and Adult Striped Bass projects reported being involved in an internal review intended to improve QA/QC, data process rates, and facilitate data analyses.

Nine projects reported using historic information to change program element design or suspected that current analyses might result in a future design change. The FWS implemented a minimum length for reporting fish caught based upon review of historic data that suggested questionable identification of <25 mm individuals. FWS also noted that a program review led in 2000 to changes and cited reduced sampling effort at Chipps Island from 3 to 2 days per week in May and June as an example and an increase to year-round sampling at Mossdale as another. A UC Davis post-doc has reviewed Bay Study and Fall Midwater Trawl data for longfin smelt and his results suggest changes to current data aggregation and analyses steps that might be taken to improve abundance calculation; Suisun Marsh researchers also referred to this work. The Townet Survey based a recent 6-survey per year standardization, in part, on analyses of historic data that suggested additional striped bass cohorts might enter the population after the traditional index was set, particularly in cool years. The Kodiak Trawl Survey reiterated that the survey's initiation was based, in part, on use of historic information confirming the gear's superiority for capturing adult delta smelt. Historic information was also used by the North Bay Aqueduct Survey to determine if sampling effort could be reduced and still meet the criteria of the Delta Smelt Biological Opinion. Finally, the Resident Fishes Survey proposes to produce a comprehensive data report with an evaluation of data biases and estimation errors, statistical power analyses and recommended changes. No time frame was presented for this report.

## 8. Data Availability and Reporting

This portion of the fish monitoring program element review focuses on data availability and reporting. All 16 fish monitoring program elements provided information used in this summary. Both past and future efforts were queried, although respondents were asked to only consider past reporting efforts over the last ten years (1994 – 2003).

### 8.1. Data availability and use of the World Wide Web:

Data from 13 of the16 fish monitoring program elements (81%) is readily available to the public, although all data are publicly available upon request (Table 8.1). Data from the entire period of record is generally posted by those program elements with publicly available data. Nearly 70% (9 of 13) of the program elements with publicly available data use the Bay-Delta Tributaries Database (BDAT) as the public data repository. The remaining four program elements store data on computers within DFG offices. Two programs (Bay Study, Fall Midwater Trawl and SummerTownet) store data on both the BDAT and on computers within DFG offices. The SWP and CVP fish salvage monitoring program elements store data on BDAT, but DFG staff also maintains a dedicated FTP site on the DFG web page to facilitate the high volume of requests for these data.

Twelve of the 16 program elements (75%) reported some level of reporting on the World Wide Web (Table 8.1), although the Bay Study reported its web-based information is out of date. Web page information includes study design and metadata information (e.g., sampling site maps, sampling gear and frequency), as well as tabular and graphical data summaries of organism abundance and distribution (Table 8.2). The Beach Seine, 20 mm Survey, North Bay Aqueduct (NBA), and Chipps, Sacramento, and Mossdale trawl surveys use web based reporting extensively to disseminate data and summary information in near real time (Table 8.2). DFG staff distributes weekly SWP and CVP ESA fish salvage data summaries via email between December and June.

### 8.2. Past reporting

All fish monitoring program elements provided information on the production of written documents over the last ten years (1994-2003). Written documents included journal articles, IEP technical reports, IEP Newsletter articles, and other types of products (e.g., other agency reports, popular articles, poster presentations, and workshop summaries). This survey also queried the level of staff involvement in the production of journal articles, technical reports and IEP Newsletter articles. Responses were examined to determine if the document was entirely produced by IEP staff, produced by others outside IEP with IEP staff as co-authors, or produced entirely by others outside IEP. The document citation was used to determine the level of staff involvement in the production of written documents.

The type and number of written products varied widely among fish monitoring program elements (Table 8.1). With the exception of the CVP fish Salvage monitoring program,

technical reports were rarely used to report program element information. In contrast, IEP Newsletter articles were the dominant form of written communication used by almost all monitoring program elements. With the exception of the Resident Fishes Survey and juvenile sturgeon survey, all program elements reported production of at least one peer-reviewed journal article between 1994 and 2003. Most of these articles were produced with program element staff as co-authors (Table 8.2). The Suisun Marsh monitoring program reported the largest number of journal articles (15) followed by the Bay Study (11), and Fall Midwater Trawl (9), and Summer Townet surveys (7).

As documented in earlier sections, several fish monitoring program elements have existed for more than 20 years; however, results presented here were standardized to only consider written products prepared over the last ten years (1994 – 2003). A more complete listing of written documents produced from IEP efforts and funding, including the fish monitoring program elements, is available at http://www.iep.ca.gov/report/.

Reporting topics for journal articles, technical reports, or Newsletter articles generally fell into four categories: status and trends, program element sampling design, species-specific information, or invasive species (Table 8.2). Species-specific articles were most common, focusing either on sport fish (e.g., striped bass, sturgeon, or American shad) or species of special concern (e.g., splittail, surfperch, delta smelt, or Chinook salmon).

The fish monitoring program elements reported producing a number of “other products.” In fact, on average the same number of other products were produced as peer-reviewed journal articles (Table 8.1). The type of other products generally fell into eight categories: 1) progress reports, 2) popular articles, 3) graduate theses and dissertations, 4) consultant technical reports, 5) contributions to biological opinions, 6) posters, 7) workshop summaries, and 8) agency sponsored San Francisco Bay planning reports (Table 8.2). Clearly, a substantial amount of staff effort has gone into the production of other products.

Staff from all 16 fish monitoring program elements plan on producing several written and/or oral products between 2004 and 2007 (Table 8.1). Most commonly sited products were journal articles or Newsletter articles (Table 8.2). Historical numbers of written products produced, suggest the plans for new products proposed by several program elements are overly optimistic.

Table 8.1. Summary of IEP fish monitoring survey data availability and reporting between 1994 and 2003.

| Survey | Data Publicly Available on website | Data Storage Locations | Web page reporting | Number of Journal Articles | Number of Technical Reports | Number of Newsletter Articles | Other products[1] | New Products planned by 2007[1] |
|---|---|---|---|---|---|---|---|---|
| **Survey Group 1: Multiple, Fixed Location Sampling** | | | | | | | | |
| Beach Seine | Yes | BDAT[2] | Yes | 3 | 0 | 4 | 7 | 5+ |
| Bay Study | Yes | BDAT and DFG offices | Yes | 13 | 4 | 19 | 23 | 20 |
| Fall Midwater Trawl | Yes | BDAT and DFG offices | Yes | 9[3] | 3 | 24 | 3 | 9 |
| Summer Tow-net | Yes | BDAT and DFG offices | Yes | 7[4] | 2 | 23 | 3[5] | 8 |
| 20 mm Survey | Yes | DFG offices | Yes | 3 | 0 | 18 | 2 | Yes, no specifics given |
| Spr. Kodiak Trawl | Yes | DFG offices | Yes | 0 | 0 | 2 | 0 | 4 |
| Suisun Marsh | Yes | BDAT | No | 15 | 0 | 5 | 5 | 10 |
| NoBay Aqueduct | Yes | DFG offices | Yes | 2 | 0 | 20[6] | 2[7] | 3+ |
| **Survey Group 2: Fixed Strata, Random Location** | | | | | | | | |
| Resident Fishes | No | DFG offices | No | 0 | 1 | 7 | 0 | 2 |
| **Survey Group 3: Single, Fixed Location Sampling** | | | | | | | | |
| SWP and CVP Fish Salvage | Yes | BDAT and DFG FTP site | Yes | 7[8] | 22[8] | 9 | 5+ | 6 |
| Chipps | Yes | BDAT | Yes | 4[9] | 2 | 4[9] | 7[9] | 8+ |
| Sac Trawl | Yes | BDAT | Yes | 1[10] | 0 | 4[9] | 7[9] | 8+[10] |
| Moss Trawl | Yes | BDAT | Yes | 1[10] | 0 | 4[9] | 7[9] | 8+[10] |
| **Survey Group 4: Flexible Location Sampling** | | | | | | | | |
| Adult Sturgeon | No | DFG offices | No | 1 | 0 | 0 | 1 | 2 |
| Juv. Sturgeon | Yes | DFG offices | No | 0 | 0 | 0 | 0 | 2 |
| Ad. Striped Bass | No | DFG offices | Yes | 2 | 0 | 2 | 0 | 2 |
| **Mean (Range)** | **---** | **---** | **---** | **3.8 (0-15)** | **2.1 (0-22)** | **7.2 (0-24)** | **3.2 (0-23)** | **5.1 (2-20)** |

[1] Other products and new products include written reports and articles, poster and oral presentations, and workshop summaries, including products not reported by questionnaire responses but identified by report authors based on outside knowledge.
[2] BDAT: Bay-Delta Tributaries database, available at WWW.IEP.water.ca.gov.
[3] Three articles are the same as those reported for the Bay Study.
[4] All articles are the same as those reported for the FMWT and three articles are the same as those reported for the Bay Study.
[5] Same products as those reported for FMWT.
[6] Eighteen articles are the same as those reported for the 20 mm Survey.
[7] Same products as listed for 20 mm Survey (1 dissertation and 1 thesis).
[8] CVP reference list obtained from http://www.usbr.gov/pmts/tech_services/tracy_research/TracyReports.htm.
[9] Same products as reported for the Beach Seine Survey.
[10] Same products as reported for the Chipps Island Trawl.

Table 8.2. Details about IEP fish monitoring survey data and products.

| Survey | Data Publicly Available | Data Locations | Web page reporting | Number of Journal Articles[1] | Number of Technical Reports[2] | Number of Newsletter Articles[2] | Other products | New Products planned by 2007 |
|---|---|---|---|---|---|---|---|---|
| **Survey Group 1: Multiple, Fixed Location Sampling** | | | | | | | | |
| Beach Seine | Data is publicly available for all years in which sampling occurred (1976 to present). | Available through BDAT. Data (with initial quality check) are uploaded weekly. Final quality check data are uploaded within 3 months after field season ends. | Yes. All salmon coded wire tag recovery data are posted on a DFG web page. Beach seine real-time data are posted on the DFG real-time web page. | 3 total, all produced by program staff. Three articles produced by staff before 1994. Except for one 1997 article on splittail, all articles deal with salmon. | None. | 4 total, all produced by program staff. All articles deal with salmon. | 7 total. 6 annual progress reports, and 1 program review report. Three products produced before 1994. | 5+ total. 1 journal article, various Newsletter articles, various presentations (workshops and professional meetings). |

| Survey | Data Publicly Available | Data Locations | Web page reporting | Number of Journal Articles[1] | Number of Technical Reports[2] | Number of Newsletter Articles[2] | Other products | New Products planned by 2007 |
|---|---|---|---|---|---|---|---|---|
| Bay Study | Data is available for all years in which sampling occurred (1980-present). | Data from 1980-94 is available on the IEP web page. All data is stored in dBASE and Access files at DFG offices. Data is available within 3 months after field season ends. | Yes. Outdated information on abundance indices and life history information | 13 total, 2 articles produced by program staff, 3 produced with staff as co-authors, and 8 produced by others outside the program. Two articles produced by staff before 1994. | 4 total. 3 reports produced by staff, 1 report produced with staff as co-authors. | 19 total. All articles produced by program staff. 8 articles (42%) focused on status and trends of Bay species, 6 articles (31%) focused on status and trends of splittail and longfin smelt, 3 articles (16%) focused on crabs. 1 article (5%) focused on surfperch, 1 article (5%) focused on jellyfish. | 23 total. 3 theses, 2 dissertations, 2 popular articles, 6 consultant technical reports, 5 agency technical reports, and 5 agency sponsored reports for Bay planning. | 20 total. 11 journal articles, 1 technical report, 4 Newsletter articles (3 status and trends edition), 1 thesis, and 3 oral presentations at professional meetings. Are the articles to be written with other DFG staff reported twice here – for example, the LW products reported for Bay Study and FMWT? |

| Survey | Data Publicly Available | Data Locations | Web page reporting | Number of Journal Articles[1] | Number of Technical Reports[2] | Number of Newsletter Articles[2] | Other products | New Products planned by 2007 |
|---|---|---|---|---|---|---|---|---|
| Fall Midwater Trawl | Data is available for all years in which sampling occurred (1967-present). No sampling in 1974 or 1979; incomplete sampling in 1969 and 1976 | Uploaded to BDAT with duplicate data set maintained at DFG. | Yes. Annual abundance indices for 5 species of fish available in tabular and graphical format. | 9 total. 2 produced by program staff, 6 produced with staff as co-authors. 6 articles (67%) focus on striped bass. 2 articles (22%) focus on splittail. 1 article (11%) focuses on shrimp. Three articles produced by staff before 1994. | 3 total. Annual IEP reports and California Fish and Game updates produced by program staff. Three reports produced by staff before 1994. | 24 total. All articles produced by program staff. 9 articles (38%) summarize survey data. 9 articles (38%) focus on striped bass. 2 articles (8%) focus on American shad. 2 articles (8%) focus on delta smelt. 2 articles (8%) consider striped bass and American shad. | 3 total. 1 striped bass workshop summary, 2 posters. | 9 total. 5 journal articles, 1 IEP tech. Report, 3 Newsletter articles (annual status and trends edition) |

| Survey | Data Publicly Available | Data Locations | Web page reporting | Number of Journal Articles[1] | Number of Technical Reports[2] | Number of Newsletter Articles[2] | Other products | New Products planned by 2007 |
|---|---|---|---|---|---|---|---|---|
| Summer Townet | Data is available for all years in which sampling occurred (1959 – present) | Uploaded to BDAT. | Yes. The TNS has web-based data presentations of program data. These include bubble plots and length frequencies of the most frequently sampled fish. | 7 total. Same as for the FMWT. | 2 total. Same as for FMWT. | 23 total. All articles produced by program staff. 12 articles (52%) summarize survey data. 10 articles (44%) focus on striped bass. 1 article (4%) focuses on delta smelt. | 3 total. Same as for the FMWT. | 8 total. 3 journal articles, 2 IEP tech. Reports, 3 Newsletter articles (annual status and trends edition). |
| 20 mm Survey | Data is available for all years in which sampling occurred (1994 – present) | All data is stored in a MS Access database at DFG offices. Data is available within 72 hours of sampling. | Yes, fish CPUE density data, fish length data, and zooplankton CPUE density data for each survey available via a DFG web page. | 3 total. 2 produced by program staff, and 1 produced with staff as a co-author. | None. | 18 total. All articles produced by program staff. All articles deal with delta smelt. | 2 total. 1 dissertation and 1 thesis. | Yes but no specifics given. |
| Spring Kodiak Trawl | Data is available for all years in which sampling occurred (2002-present) | All data is stored at DFG offices. Data is generally available two days after a survey is completed. | Yes. The DFG web page includes bubble plots of delta smelt distribution and maturity status. | None. | None. | 2 total. Both articles produced by program staff. 1 article deals with survey design, 1 article deals with survey results. | None. | 4+ total. 1 journal article using Kodiak trawl data, 1 Newsletter article, 2+ oral presentations. |

| Survey | Data Publicly Available | Data Locations | Web page reporting | Number of Journal Articles[1] | Number of Technical Reports[2] | Number of Newsletter Articles[2] | Other products | New Products planned by 2007 |
|---|---|---|---|---|---|---|---|---|
| Suisun Marsh | Data is available for all years in sampling occurred (1979 – present) | All data is uploaded to BDAT. Data is generally available within 5 months of field sampling. | No. | 15 total. 5 articles on introduced species, 5 articles on fish autecology, 3 articles on fish community ecology, 1 article on contaminants, and 1 article on fish physiology. Six articles were produced before 1994. | None. One report was produced before 1994. | 5 total. 2articles on introduced species, 1 article on fish diets, 1 on mysid shrimp, and 1 on fish physiology. | 5 total. 1 dissertation, 1 thesis, 1 abstract, and 2 books. | 10-22 total. 5-10 journal articles, 1-4 Newsletter articles, 4-8 oral presentations at professional meetings. |
| North Bay Aqueduct | Data is publicly available for all years in which sampling occurred (1994 – present) | All data is stored in an MS Access database at DFG offices. Data is available within 72 hours of sampling. | Yes, fish CPUE density data, weighted entrainment, and catch summary. | 2 total. 1 produced by staff and 1 produced by an individual outside the program. | None | 20 total. Same articles as listed for the 20 mm Survey, except for 2 articles that focus on NBA survey. | 2 total. Same as for 20 mm Survey (1 dissertation and 1 thesis). | 3+ total. NBA technical report and Newsletter articles. |

| Survey | Data Publicly Available | Data Locations | Web page reporting | Number of Journal Articles[1] | Number of Technical Reports[2] | Number of Newsletter Articles[2] | Other products | New Products planned by 2007 |
|---|---|---|---|---|---|---|---|---|
| **Survey Group 2: Fixed Strata, Random Location** | | | | | | | | |
| Resident Fishes | Data is not available to the public. Data collected between 1980 and present. | Data is stored on a server and several personal computers at DFG | None | None | 1 total. Focuses on white catfish. | 7 total. 4 on resident fishes survey, 2 on large mouth bass, 1 on resident fishes in shallow-water habitats | None | 2 total. One journal article. One comprehensive, retrospective technical report. |
| **Survey Group 3: Single, Fixed Location Sampling** | | | | | | | | |
| SWP and CVP Fish Salvage | Data from 1993 – present is available to the public. | Data is stored on BDAT and is also available at the DFG FTP site. Data is generally available 3-6 months after sampling occurs. | Yes. April – June data are reported on the Real-time monitoring web page. | 7 total. 2 by program staff and 3 with staff as a co-author, and 2 produced by staff outside the program. | 22 total. All on CVP fish salvage | 9 total. 8 on fish salvage status and trends and 1 one Chinese mitten crabs. | 5+ total. 1 technical report, 1 biological assessment, 1 biological opinion, and numerous DAT recommendations. Four products produced before 1994. | 6 total. 1 journal article, 1 technical report, 3 status and trends Newsletter articles, and 1 presentation. |
| Chipps Island Trawl | Data is publicly available for all years in which sampling occurred (1976 – present) | Available through BDAT. Data (with initial quality check) are uploaded weekly. Final quality check data are uploaded by November of each year. | Yes. All salmon coded wire tag recovery data are posted on a DFG web page. | 4 total. Same as reported for Beach Seine survey, in addition to 1 splittail article. | 2 total. Focus on salmon and delta smelt. | 4 total. Same as reported for Beach Seine survey. | 7 total. Same as reported for Beach Seine Survey. | 8+ total. 4 journal articles, 4 Newsletter articles (3 status and trends). Several oral presentations at IEP meetings and professional meetings. |

| Survey | Data Publicly Available | Data Locations | Web page reporting | Number of Journal Articles[1] | Number of Technical Reports[2] | Number of Newsletter Articles[2] | Other products | New Products planned by 2007 |
|---|---|---|---|---|---|---|---|---|
| Sacramento Trawl | Data is publicly available for all years in which sampling occurred (1988 – present) | Available through BDAT. Data (with initial quality check) are uploaded weekly. Final quality check data are uploaded by November of each year. | Yes. All salmon coded wire tag recovery data are posted on a DFG web page. | 1 total. Same as reported for Beach Seine survey. | None | 4 total. Same as reported for Beach Seine survey. | 7 total. Same as reported for Beach Seine Survey. | 8+ total. Same as reported for Chipps Is. Trawl. |
| Mossdale Trawl | Data is publicly available for all years in which sampling occurred (1988 – present) | Available through BDAT. Data (with initial quality check) are uploaded weekly. Final quality check data are uploaded by November of each year. | Yes. All salmon coded wire tag recovery data are posted on a DFG web page. | 1 total. Same as reported for Beach Seine survey. | None | 4 total. Same as reported for Beach Seine survey. | 7 total. Same as reported for Beach Seine Survey. | 8+ total. Same as reported for Chipps Is. Trawl. |

| Survey | Data Publicly Available | Data Locations | Web page reporting | Number of Journal Articles[1] | Number of Technical Reports[2] | Number of Newsletter Articles[2] | Other products | New Products planned by 2007 |
|---|---|---|---|---|---|---|---|---|
| **Survey Group 4: Flexible Location Sampling** | | | | | | | | |
| Adult Sturgeon | Data is not publicly available. Data collected between 1954 and present. | All data is kept at DFG offices. Data is stored on a server and several personal computers. Most data available within one month of field sampling, although age data may take longer. | No. | 1 total. 1 prepared by program staff on white sturgeon. Seven other articles were produced before 1994. | None. | None. | 1 total. DFG comments to NOAA-Fisheries on green sturgeon listing. | 2 total. 1 comprehensive, retrospective technical report and 1 Newsletter article. |
| Juvenile Sturgeon | Data is available for all years in which sampling occurred (1995 - Present) | All data is kept at DFG offices. Data is stored on a server and several PC's. Most data available within one month of field sampling, although age data may take longer. | No. | None. | None. | None. | None. | 2 total. 1 technical report and 1 Newsletter article. |

| Survey | Data Publicly Available | Data Locations | Web page reporting | Number of Journal Articles[1] | Number of Technical Reports[2] | Number of Newsletter Articles[2] | Other products | New Products planned by 2007 |
|---|---|---|---|---|---|---|---|---|
| Adult Striped Bass Tagging | Data is not publicly available. Data collected between 1969 and present. | All data kept at DFG offices. Data stored on a server and several PCs. Most data available within one month of field sampling, although age data may take longer. | Yes. Some static plots posted on DFG web page. | 2 total, 2 produced with program staff as co-authors. Four articles were produced by staff before 1994. | None. | 2 total. Both articles produced by others outside the program. | None. | 2 total. 1 comprehensive, retrospective technical report and 1 IEP Newsletter article. |

[1] Number of documents produced before 1994 is noted if information was provided in the questionnaire, but these documents are not included in the total.
[2] Means do not include duplicate reporting of products.

## 9. Customer Needs and Use

For purposes of this survey, a customer is defined as an entity or person who uses the data or results generated from a fish monitoring Survey. Survey responses assume that two or more requests per year constitute frequent use, an annual request is moderate use, and less than annual is rare. Table 9.1 shows how frequently various customers use the 16 different surveys.

Table 9.1. Survey Customers and Frequency of Use

| Customer* | Frequent use of data or information | Moderate use of data or information | Rare use of data or information |
|---|---|---|---|
| **IEP Agencies+** | | | |
| **USFWS** | Beach Seine, Summer Townet, 20 mm | Summer Townet | |
| **DFG** | Beach Study, Beach Seine, Fall Midwater Trawl, Summer Townet, Spring Kodiak Trawl, Suisun Marsh, Chipps Island Trawl, Mossdale Trawl, Sacramento River Trawl, SWP and CVP Fish Salvage, Adult Bass | Adult Sturgeon, Juvenile Sturgeon | Resident Fishes |
| **DWR** | 20 mm, Suisun Marsh, North Bay Aqueduct, SWP and CVP Fish Salvage, Adult Bass | Summer Townet | Resident Fishes, Adult Sturgeon, Juvenile Sturgeon |
| **USBR** | 20 mm, SWP and CVP Fish Salvage | Suisun Marsh | |
| **USGS** | Suisun Marsh, SWP and CVP Fish Salvage | Beach Seine, Resident Fishes | Beach Study, 20 mm, Chipps Island Trawl, Mossdale Trawl, Sacramento River Trawl |
| **NOAA Fisheries** | | Beach Study, Chipps Island Trawl, Mossdale Trawl, Sacramento River Trawl | |
| **USACE** | | 20 mm | |
| **USEPA** | SWP and CVP Fish Salvage | 20 mm | |
| **CALFED Programs** | | | |
| **DFG (ERP Restoration Planning)** | Beach Study fish, Summer Townet, Suisun Marsh | | |
| **DAT/WOMossdale Trawl** | Beach Study, Spring Kodiak Trawl, Chipps Island Trawl, Mossdale Trawl, Sacramento River Trawl, SWP and CVP Fish Salvage | | |
| **EWA** | Beach Study, Chipps Island Trawl, Mossdale Trawl, Sacramento River Trawl, SWP and CVP Fish Salvage | | |
| **ESA Programs** | SWP and CVP Fish Salvage | | |

| Customer* | Frequent use of data or information | Moderate use of data or information | Rare use of data or information |
|---|---|---|---|
| **Through-Delta PWT** | | Beach Study, Chipps Island Trawl, Mossdale Trawl, Sacramento River Trawl | |
| **DCC PWT** | | Beach Study, Chipps Island Trawl, Mossdale Trawl, Sacramento River Trawl | |
| **Sport Fish Mgmt. Entities** | | | |
| **DFG** | Adult Bass | Beach Seine, Fall Midwater Trawl, Summer Townet, Resident Fishes, Adult Sturgeon, Juvenile Sturgeon | |
| **Regulatory Agencies** | | | |
| **USEPA** | | Suisun Marsh | |
| **DFG** | Beach Study, Beach Seine, Chipps Island Trawl, Mossdale Trawl, Sacramento River Trawl, Adult Bass | Fall Midwater Trawl, Adult Sturgeon, Juvenile Sturgeon | |
| **NOAA Fisheries** | Beach Seine, SWP and CVP Fish Salvage | Beach Study, Chipps Island Trawl, Mossdale Trawl, Sacramento River Trawl, Adult Bass, Juvenile Sturgeon | Suisun Marsh |
| **USFWS** | Beach Study, Beach Seine, Suisun Marsh, North Bay Aqueduct, Chipps Island Trawl, Mossdale Trawl, Sacramento River Trawl, SWP and CVP Fish Salvage | Fall Midwater Trawl, Summer Townet, Adult Sturgeon, Juvenile Sturgeon, Adult Bass | |
| **SWRCB** | | | Beach Seine, Adult Sturgeon, Juvenile Sturgeon, Adult Bass |
| **RWQCB** | | | |
| **Other government, academic, NGO, or consultant entities** | | | |
| **Other government agencies**** | North Bay Aqueduct | Beach Seine, | Beach Seine, 20 mm, Chipps Island Trawl, Mossdale Trawl, Sacramento River Trawl, Adult Bass |
| **NGO**** | Beach Seine, SWP and CVP Fish Salvage, Beach Study, Chipps Island Trawl, Mossdale Trawl, Sacramento River Trawl, Suisun Marsh | Adult Bass, Beach Seine, Suisun Marsh | Fall Midwater Trawl, SWP and CVP Fish Salvage |
| **Private consultants**** | Beach Seine, Suisun Marsh, SWP and CVP Fish Salvage | Beach Study, Fall Midwater Trawl, Summer Townet, 20 mm, Chipps Island Trawl, Mossdale Trawl, Sacramento River Trawl, SWP and CVP Fish Salvage | Fall Midwater Trawl, Chipps Island Trawl, Mossdale Trawl, Sacramento River Trawl |

| Customer* | Frequent use of data or information | Moderate use of data or information | Rare use of data or information |
|---|---|---|---|
| **Academic Institutions**** | Beach Seine, Fall Midwater Trawl, Suisun Marsh, SWP and CVP Fish Salvage | 20 mm, Spring Kodiak Trawl, Adult Bass, SWP and CVP Fish Salvage | Beach Study, Chipps Island Trawl, Mossdale Trawl, Sacramento River Trawl |
| **MWD of Southern CA** | SWP and CVP Fish Salvage | | |
| **CUWA** | SWP and CVP Fish Salvage | | |
| **CDM** | | SWP and CVP Fish Salvage | |

*Not all consultant entities that use Survey data or information may be listed. The questionnaire only requested the name of the consultant entity where frequent data or information use occurs.

** NOTE: This table consolidates multiple responses for other government agencies, non-government agencies (NGOs), private consultants, and academic institutions into each category.

- Other government agency responses include CalTrans, California Department of Parks and Recreation, California Coastal Conservancy, National Park Service, Solano County Water Agency, and ESD Oak Ridge National Laboratory.
- NGO responses include the San Francisco Estuary Institute, Bay Institute, Marine Science Institute, Point Reyes Bird Observatory, San Joaquin River Group, Fish First, Save the Bay, Suisun Marsh Agencies, and Montezuma Wetlands.
- Consultant responses include Hanson Environmental Inc, Stillwater Sciences, Jones and Stokes, BJ Miller, Tenera Environmental, URS Greiner Woodward Clyde (and many subconsultants), SP Cramer & Associates, Natural Resource Scientists Inc., Entrix, Eco-Logic Engineering, Mirant Energy.
- Academic institution responses include requests for data and information by graduate students and professors at these universities for theses and other studies, such as grant funded research. Lists requests within the past 3 years. Universities named in survey responses include UC Davis, San Francisco State University, Cal State Fresno, Cal State Long Beach, San Diego State University, UC Berkeley, UC Los Angeles, and UC Santa Cruz.

Appendix B contains unabridged responses.

Questionnaire responses generally report that customers are very satisfied (i.e., no complaints to positive feedback) with the quality of the monitoring data. Customers are, however, overwhelmed by the quantity of data. Another problem for customers has been data gaps and the lack of year-round sampling in past years for some surveys. Special study data are sometimes difficult to access electronically and therefore not readily available to the public.

The most valuable aspect of many surveys is the longevity, combined with temporal and spatial consistency of the sampling. Some customers emphasized the added value of surveys by including species other than the usual IEP targets. One of the more challenging aspects, both in the past and looking forward, is how to maintain the above consistency of sampling—especially for species that do not have traditional human-assigned values.

The types of customer use most frequently cited in questionnaire responses include environmental documentation, project analysis, regulatory, and research applications. Long-term abundance and distribution trends, coupled with life history information, inform water operation decisions, EWA actions, and species status and/or recovery criteria. Survey data also informs site-specific information and project impact

assessment, particularly regarding potential impacts to threatened salmonids in the Bay-Delta. For example, data is used to manage water exports and ensure that all pumping is in compliance with the ESA take limits of listed species. Academic institutions, in addition to regulatory agencies, utilize fish monitoring data to supplement graduate and post-doctoral work on fish ecology.

As discussed in the following sections, each of the four identified survey groups (as previously defined in Table 2.1) serve different primary customers who used the data and information generated by monitoring Surveys.

## 9.1. Survey Group 1

The geographically broad to narrow systematic sampling range Surveys frequently serve all customer types: IEP, CALFED, sport fish, and regulatory agencies, as well as other government, academic, NGO, and consultant entities.

These IEP fish monitoring surveys track long-term abundance and distribution trends for special status species (e.g., delta smelt, splittail, salmonids) and sport fish species (e.g., striped bass). Surveys also provide species-specific life history and population status information across seasons and years. Such data includes long-term monitoring and trends, some of which date back almost 50 years. Customers generally expressed satisfaction with the quality of these monitoring data. Customers also recognized challenges and areas for improvement. Specifically, they emphasized the need to maintain sampling consistency, ensure year-round sampling (i.e., prevent data gaps), and organize data in readily available and presentable formats that do not overwhelm customers.

Monitoring surveys provide population abundance and distribution data on salmonids and species of concern in the Delta. The information aids environmental documentation and project analysis of water operations, EWA actions, and recovery criteria. Project impact assessment includes site-specific information to predict the potential impact on species due to the operation of the Central Valley Project (CVP) and State Water Project (SWP). Survey data also informs broader Delta-wide management decisions and facilitates regulatory management decisions.

FWS, DFG, NOAA-Fisheries, and other regulatory agencies use 20 mm, North Bay Aqueduct, and Bay Study data to regulate water exports, assess project impacts, and set annual take limits in accordance with the Endangered Species Act (ESA). NOAA uses Bay Study salmon and steelhead data to set take limits in their biological opinions, such as for Tenera Power Plant near-field sampling, SFO expansion sampling, etc. and to assess project impacts, such as for sand mining and in-Bay dredge spoil disposal. Data is used in conjunction with other sources of information to assess fish distribution and abundance during times of specific actions (e.g., EWA asset use or VAMP). The information helps estimate abundances of salmonids, delta smelt, and splittail, which contributes to determining the ESA listings for various species.

Consultants, academic researchers, and NGO staff used data from the group one Surveys in their research of the Estuary. In particular, long-term trends in fish abundance help determine the status of delta smelt, splittail, longfin smelt, and other species of concern. Information aids on-going efforts to better understand or develop life history information, population estimates, and conceptual/quantitative ecological models. This monitoring data provides a way for students, agency biologists, and visitors to experience the estuary, learn about its fishes, and obtain training in sampling procedures. This data has been a source of graduate degrees, international journal publications, and Peter Moyle's reference book, *Inland fishes of California*. Such understanding promotes the protection of listed species, while simultaneously providing biological understanding to develop innovative management approaches that balance California's diverse water demands.

9.2. Survey Group 2

The relatively broad stratified random survey serves IEP agencies and sport fish management entities interested in long-term abundance and distribution trends, and in life history information.

USGS accesses this survey information to evaluate long-term abundance and distribution trends, life-history information, population status, recruitment rates, project impact assessment, and ecological analyses (e.g., influences of exotic species). Other customers, including DFG and DWR, rarely use Resident Fishes survey data (i.e., less than once per year).

9.3. Survey Group 3

Single location, temporally systematic sampling surveys convey information to IEP, CALFED, and regulatory agencies, as well government, academic, NGO, and consultant entities with a focus on environmental documentation.

Customers integrate information from the Chipps Island, Sacramento, and Mossdale trawls with the Beach Seine Survey to assess population abundance, distribution, and life history of various fishes (e.g., salmon and splittail) in the Sacramento-San Joaquin Rivers and estuary. Data from these monitoring project elements support environmental documentation and project analysis. They provide real-time distribution and abundance information, while helping to assess interrelationships of environmental variables and fish movement.

Fish survival data, largely derived from non-IEP mark-recapture studies, are used extensively. IEP sampling recovers marked fish and supplements analyses to evaluate water project effects and management alternatives for the EWA, through-Delta PWT, and Delta Cross Channel PWT. Salvage data is used extensively by many different agencies, consultants, and institutions for a broad variety of uses. It is used for study design, abundance, and distribution trends. The data is essential for determining abundance and distribution of listed species for water operations/EWA actions.

Monitoring surveys have been used extensively to determine water project impacts on various species and the relative success of EWA and water operations management actions. The data has also been used extensively to help design fish facility studies and determine their impacts on listed species. Regulatory agencies use the data to determine patterns of fish migration through the Delta, create take limits in biological opinions and OCAPs, and establish guidelines for regulating water exports. DAT uses data as the basis for water operations and EWA actions.

Research applications include the comparison of hydroacoustic gear with trawl sampling estimates of population distributions and abundances and understanding the influence of specific facilities such as the Delta Cross Channel gates on fish emigration and entrainment. Data helps estimate abundances of salmonids, delta smelt, and splittail. These abundance estimates help determine ESA listings for various species.

### 9.4. Survey Group 4

The flexible location sampling primarily serves IEP, sport fish management, and regulatory agencies (particularly those interested in long time-series fish population data), with academics and research-focused NGOs serving as additional customers.

The unique and long time series of these data contribute to environmental documentation, project analyses, and research. However, abundance estimates derived from striped bass and sturgeon tagging contain much uncertainty. This imprecision limits the utility of the estimated long-term abundance and distribution trends, population status, harvest rates, recruitment rates, and project impact assessment for adult striped bass, adult sturgeon, and juvenile sturgeon year-class strength.

Research applications include the exploration of project impacts on fish populations. Analyses of ecological processes probe the influence of El Nino and the degree of density dependent growth and survival. Other data uses include the development of striped bass models for management and recovery of striped bass on the East Coast.

## 10. Comments and Recommended Actions

The following is a synopsis of information provided in *Section VI. Comments* from completed element questionnaires. Because element strengths described in the questionnaires are typically a subset of those in Section 5 of this report, strengths are not synopsized here.

Staff of most elements commented that new, alternative, or more frequent analytical work is appropriate. Staff of elements monitoring status of sub-adult and adult non-salmonid sport fishes reported that technical reports are necessary to evaluate and improve element effectiveness and/or efficiency.

### DFG Bay Study

*Recommended Actions*: Increase efficiency of post-data-collection phases, use indices that allow calculation of confidence intervals, re-calculate area and volume of habitat, make IEP Technical Report #63 available as PDF, add new graphic representation of data to web.

### UCD Suisun Marsh

*Recommended Actions*: Add Midwater trawl, reduce reliance on volunteers to improve efficiency.

### DFG Fall Midwater Trawl

*Recommended Actions*: Log actual depth of net during deployment.

### FWS Mossdale Trawl

*Recommended Actions*: Analyze the degree to which sampling method gives results that are representative of target populations, evaluate diel effects on catch.

### DFG 20mm

Recommended Actions: None.

### DFG NBA

Recommended Actions: None.

**DWR Salvage**

*Recommended Actions*: Increase access to data via web. Increased analytical capacity. Add trained biologist(s) or biological technician(s) to on-site staff so fish identification and processing are less suspect.

**FWS Sacramento Trawl**

*Recommended Actions*: Analyze the degree to which sampling method gives results that are representative of target populations, evaluate diel effects on catch.

**FWS Delta Juvenile Fishes Monitoring Beach Seine**

*Recommended Actions*: Analyze degree to which sampling locations and methods give results that are representative of available habitat and target populations, incorporate random sampling, sample other habitat by using different gear.

**DFG Adult Striped Bass Population**

*Recommended Actions*: Conduct and report on a thorough technical review, where the review will identify potential means and feasible means to improve efficiency, precision, and accuracy.

**DFG Adult Sturgeon Population**

*Recommended Actions*: Conduct and report on a thorough technical review, where the review will identify potential means and feasible means to improve efficiency, precision, and accuracy.

**DFG Juvenile Sturgeon Population**

*Recommended Actions*: Conduct and report on a thorough technical review, where the review will identify potential means and feasible means to improve efficiency, precision, and accuracy.

**DFG Shoreline Resident Fishes**

*Recommended Actions*: Conduct and report on a thorough technical review, where the review will identify potential means and feasible means to improve efficiency, precision, and accuracy.

**FWS Chipps Island Trawl**

*Recommended Actions*: Assess limitations of current data by experimenting with alternative gear, conduct new analyses on extant data, and produce more peer-reviewed publications.

**DFG Kodiak Trawl**

*Recommended Actions*: Improve maturity data.

**DFG Summer Townet**

*Recommended Actions*: None.